for

engineers and contractors controlling the design, specification, installation and maintenance of heating, ventilating and air conditioning.

HEATING AND VENTILATING

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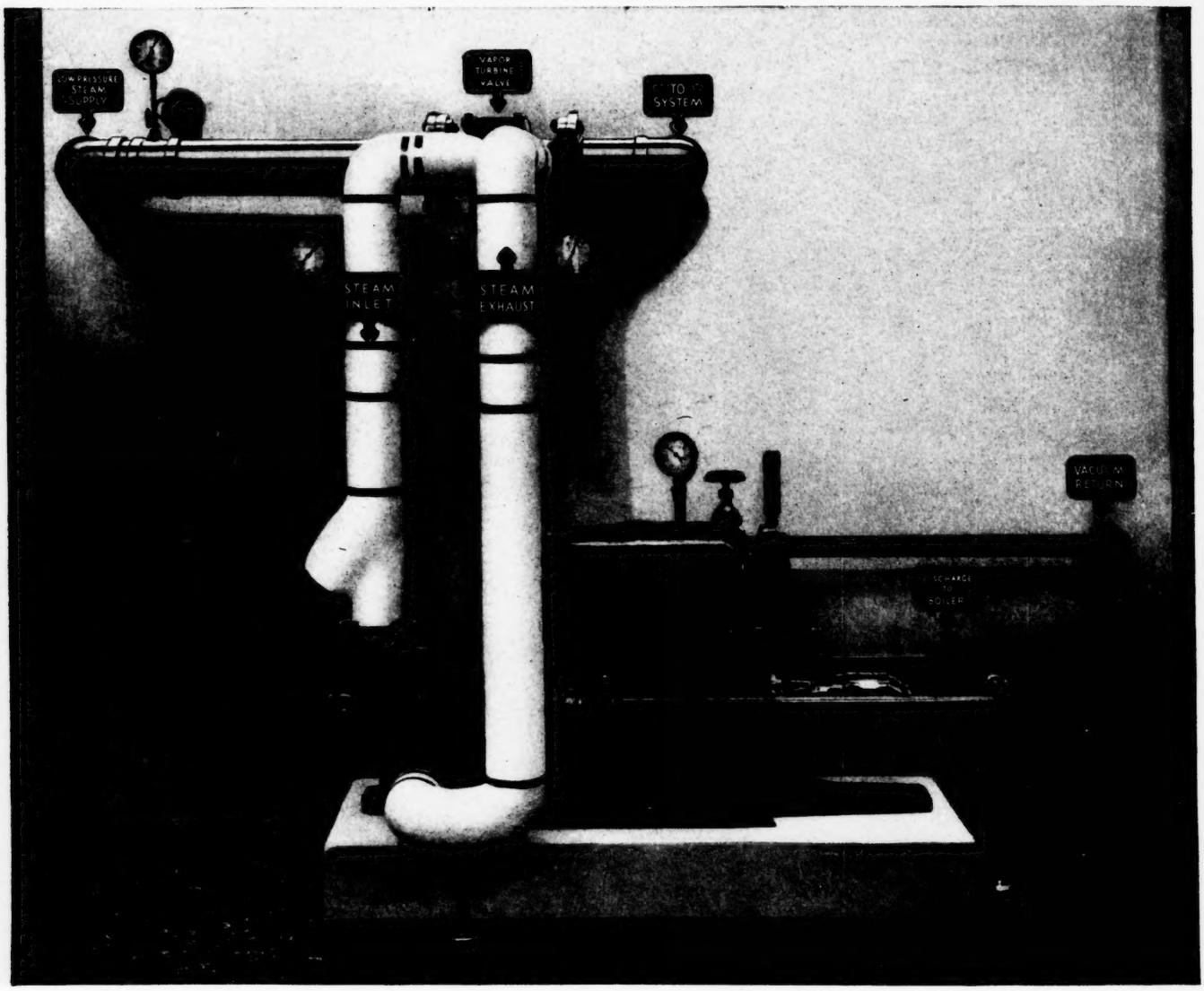
Interrupted Electric Service will not Stop this Nash Heating Pump



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

THE NASH ENGINEERING COMPANY
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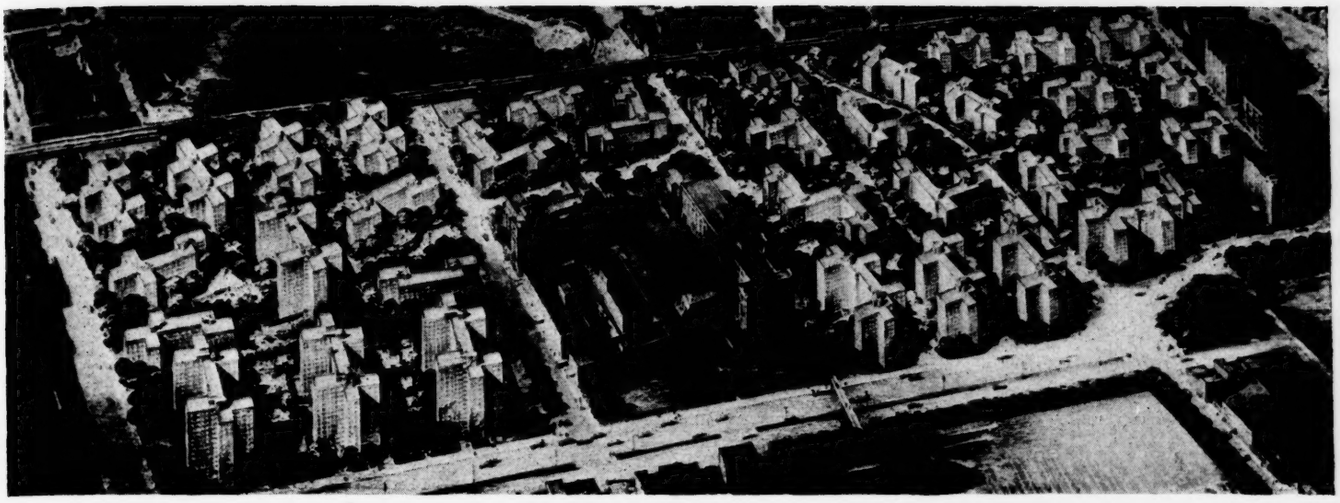


HEATING FORT GREENE HOUSES,

the largest of all government housing projects, scheduled for completion in June 1943, is here described by one of the three different consulting engineering firms involved in the design.

By MORTIMER FREUND†

"The troops marched out to the fortifications which General Greene had been erecting. General Greene had constructed a formidable line of intrenchments. Over on the marsh at Wallabout Bay (the present Navy Yard) he dug a ditch, from tide-water to a spring on the edge of the marsh, at the junction of Flushing Avenue and Portland Street. From the spring a line of earth-works was carried to the top of a hill on John Cowenhoven's farm where a strong fort was erected."

IN these words C. C. Coffin has told the story of an engineering job performed by the hard-pressed American Army in July, 1776, just before the Battle of Long Island, under the command of General Nathanael Greene, who was later destined to become one of the chief aides to George Washington in the fight which secured our liberties in an independent United States of America.

On this historic site in the Borough of Brooklyn of the City of New York, between the U.S. Navy Yard and that hill, now occupied by Fort Greene Park, men are at work again, this time constructing one of the largest, if not indeed the largest, low rental housing developments ever to be built under governmental ownership and operation. This is Fort Greene Houses. To provide wholesome living conditions for some of the inheritors of those traditions of democracy and freedom, whole city blocks have been cleared of the closely packed, worn-out, poorly equipped, dark and dingy habitations and in their place modern buildings are arising, designed to permit clean and healthy living, and so disposed as to admit plenty of sunlight and provide ample spaces for outdoor recreation free from traffic dangers.

This project is being built and will be operated by the New York City Housing Authority with funds advanced by the State of New York and is the first of the housing projects to be so financed under state legislation enacted a few years ago. All details of design have been subjected to the approval of the New York State Housing Division. The design of the buildings has been predicated upon a life of not less than fifty years and the details of design and selection of materials to be used have been governed accordingly.

Fort Greene Houses extends from Park Avenue on the north to Myrtle Avenue on the south and from Carlton Avenue on the east to Prince Street on the west. The gross area of the site is 50.57 acres and the net area 38.24 acres, 21.6% of which will be covered by buildings. Within the above named boundaries, but not included in the project, are an existing public library, school buildings and playgrounds. A two-

†Member of the firm of Eadie, Freund and Campbell, Consulting Engineers, New York, N. Y.

NOTE: Generally, descriptions of projects such as this do not appear on these pages until the project is near completion or is entirely completed. However, due to the interest in Fort Greene Houses at the present time—interest which may be somewhat dissipated by the time this project is finished—the account appears eighteen months before the project is scheduled for completion.—EDITOR

story Community and Children's Building is to be built outside of the project, which, although not a part of it, will be supplied with steam therefrom.

Although Fort Greene Houses is being built and will be operated as a single housing project, it was divided for convenience in planning into three sections. Section One, at the east end, is separated from the middle Section Two, by North Portland Avenue, which, while a through street, will be closed to general traffic by stanchions. Section Three at the west end, is separated from Section Two by Navy Street, an exclusively vehicular highway, across which an overpass will be built so that residents in Section Three can cross easily and safely into Section Two to reach the public school and library buildings noted above. At certain points driveways enter the project to afford vehicles access to the buildings.

In order to present a clear picture of the problems involved in the design of the heating systems for this project, certain facts concerning the buildings themselves should be briefly summarized.

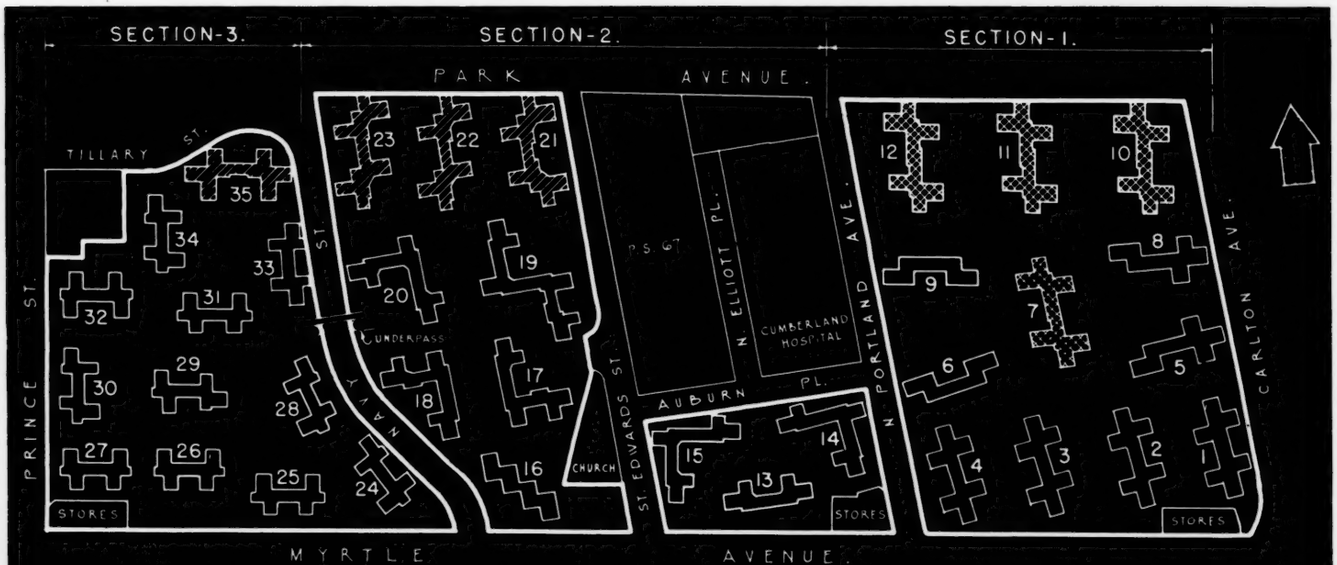
Fort Greene Houses will consist of 35 multi-story, multiple dwelling buildings, 27 of which will be 6-story, four 11-story and four 13-story. The number of rooms per apartment or dwelling unit ranges from one to eight, the number of apartments per story from 10 to 16 and the number of apartments per building from a minimum of 55 in the 6-story buildings to a maximum of 204 in the 13-story buildings. In addition there is a bathroom in each apartment. The total number of apartments in the project is 3,501 and the total number of rooms (excluding bathrooms) is 13,133, in which it is anticipated that 13,040 persons will dwell, from one to nine persons per apartment. The following table shows the total number of apartments of each size:

No. of Rooms per Apt.	No. of Apts.
1	54
2	441
3	1,125
4	753
5	1,000
6	102
7	10
8	16
Total	3,501

Each dwelling building is provided with two or more elevators and the required number of stair-halls. The administrative offices for the whole project will be located in Building No. 13 in Section Two.

Each dwelling building will have a cellar in which will be located a laundry, perambulator room, wheeltoy room, electric and gas service room, pump room containing vacuum pump set and hot water storage heater, incinerator rooms, storage rooms, and toilets. In the cellar in one building in each Section there will be craft rooms for the use of tenants, also a paint shop in another, and a boiler room in each of two buildings in each Section as described later. In those parts of cellars where service rooms or corridors do not occur, accessible crawl spaces will be provided.

In addition to the dwelling buildings there will be a separate store building in each Section, those in Sections One and Three arranged for ten store units each and that in Section Two for nine units and a small garage for use of the Management. This adds up to



NOTE ALL STORES ARE ONE STORY BUILDINGS.

PERSONS PER APARTMENT.	1	2	3	4	4A	5	6	7	8	9	TOTAL.
ROOMS PER APARTMENT.	1	2	3	4	5	5	5	6	7	8	
NUMBER OF APARTMENTS.	54	441	1,125	753	438	345	217	102	10	6	3,501
NO. OF CONSTRUCTION R'MS.	54	882	3,375	3,012	2,190	1,725	1,085	612	70	128	13,133
NUMBER OF PERSONS.	54	882	3,375	3,012	1,752	1,725	1,302	714	80	144	13,040
% TYPE	1.5	12.6	32.1	21.5	12.5	9.9	6.2	2.9	.3	.5	100%

Fig. 1. Site plan of Fort Greene Houses. The school, hospital and church in the middle of the area are not part of the project. Buildings with no cross-hatching are six stories in height; single hatching, eleven stories in height and double cross-hatched, thirteen stories.

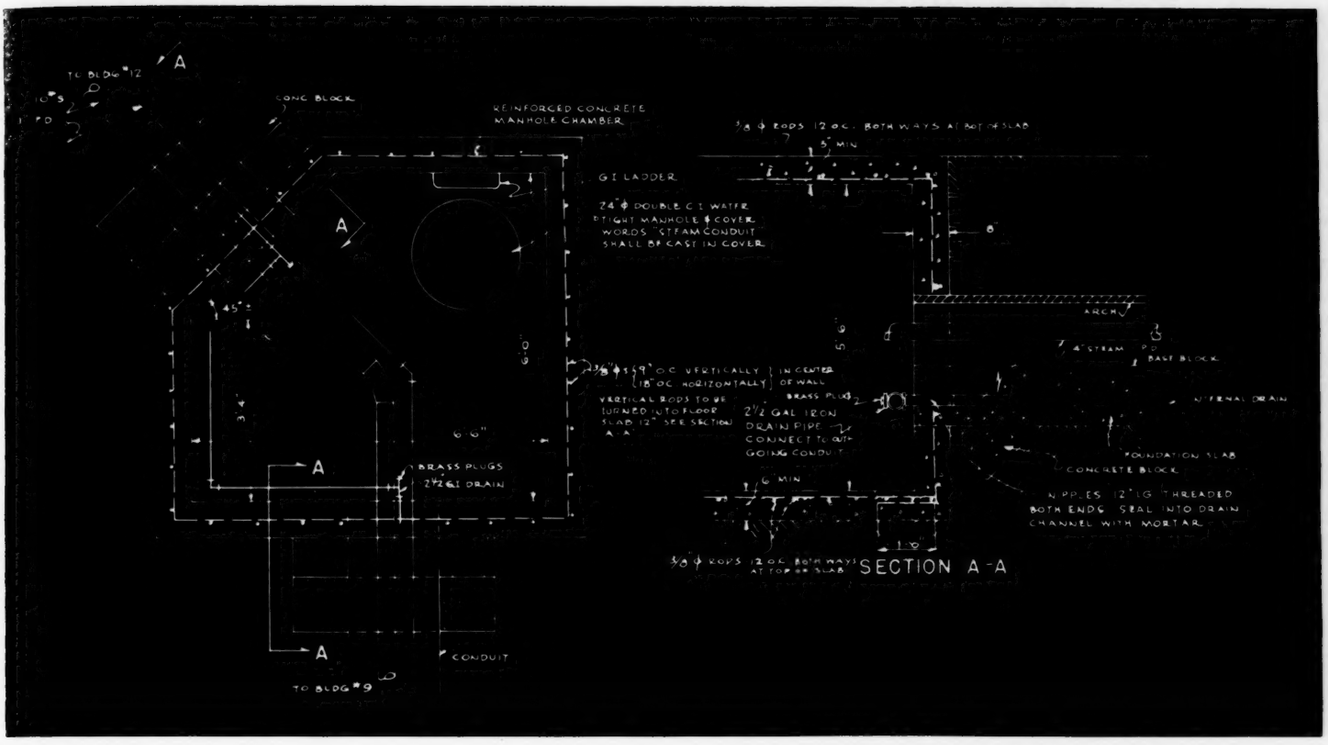

REINFORCED CONCRETE MANHOLE CHAMBER
CONC BLOCK
G.I. LADDER
24" ϕ DOUBLE C.I. WATER TIGHT MANHOLE & COVER. WORDS "STEAM CONDUIT" SHALL BE CAST IN COVER
BRASS PLUGS 2½" G.I. DRAIN
2½ GAL IRON DRAIN PIPE CONNECT TO OUT-GOING CONDUIT
INTERNAL DRAIN
FOUNDATION SLAB
CONCRETE BLOCK
NIPPLES 12" LG. THREADED BOTH ENDS SEAL INTO DRAIN CHANNEL WITH MORTAR
SECTION A-A
CONDUIT
TO BLDG #9

Fig. 2. Plan and section of manhole in the steam conduit between buildings 9 and 12, section No. 1. Syska & Hennessy, consulting engineers.

a total of 38 buildings for the whole project.

The buildings are built with flat concrete slabs supported on wide and shallow concrete beams built into concrete columns. The exterior walls are 10½ in. thick, consisting of exterior brick facing backed by hollow tile with 2 in. of furring and plaster on the interior. These exterior walls are supported on concrete spandrel beams integral with the frame. No plaster is applied to concrete structural members or slabs.

Cast iron radiators are used, in general, for heating, floor standing excepting where wall hung sections are used in entrance vestibules and where supported from ceilings in cellar spaces. Supply and return risers and run-outs from these to radiators are exposed and serve as heating surface, for which due allowance has been made in sizing radiators. In stair-halls, bathrooms and kitchens blank supply and return risers of equal pipe size serve as heating surface, unless special exposure requires cast iron radiators in addition. These risers are provided with loops at the topmost story or in roof bulkheads, as the case may be, to take care of additional exposure at these points. The radiators in the topmost story are of larger size than in other stories, so as to take care of roof exposure.

The heating requirements for rooms within apartments were established as 70F with an outdoor temperature of 0F. For other spaces the temperature requirements under similar outdoor conditions were established as follows:

Community Rooms	70F
Community Kitchen	65
Offices	70
Craft Rooms	70
Laundries	60
Washing Machine Storage	50
Perambulator Rooms	50
Wheel Toy Rooms	50
Corridors	50
Stair Halls	50
Entrances	50

Drying in each cellar laundry will be accomplished by producing 15 changes of air per hour with two disc type exhaust fans discharging through louvers in the exterior walls, but no additional heating surface is provided for such air change.

In all apartment rooms the radiators have been located below the windows with the end of the radiator in line with the window jamb at the end nearer the risers. Exception was made where this would have resulted in run-outs of insufficient length to provide for expansion. Risers will be anchored at mid-points and no expansion loops or joints will be provided.

Two-pipe, up-feed, low-pressure vacuum return systems with sub-atmospheric control will be used to circulate steam to the radiators and to return the condensation to the boilers. There will be six independent heating systems, each supplied from its own boiler plant. Two boiler plants, each supplying from 4 to 9 buildings, will be located in each Section. One of the boiler plants in Section Three, however, will also supply three buildings in Section Two, the steam supply and condensate return piping and wiring for electric controls being carried across under Navy Street in ducts. No. 6 (Bunker C) oil will be used as fuel.

The decision to install semi-central heating plants was based upon careful analysis of the relative installation and operating costs of such an arrangement as compared with an individual boiler plant for each building, or a single central boiler plant for the whole project.

The heating system of each building will be under single control, the control valve being located in the cellar of that building, but the operating control board for all buildings in each group will be located in the

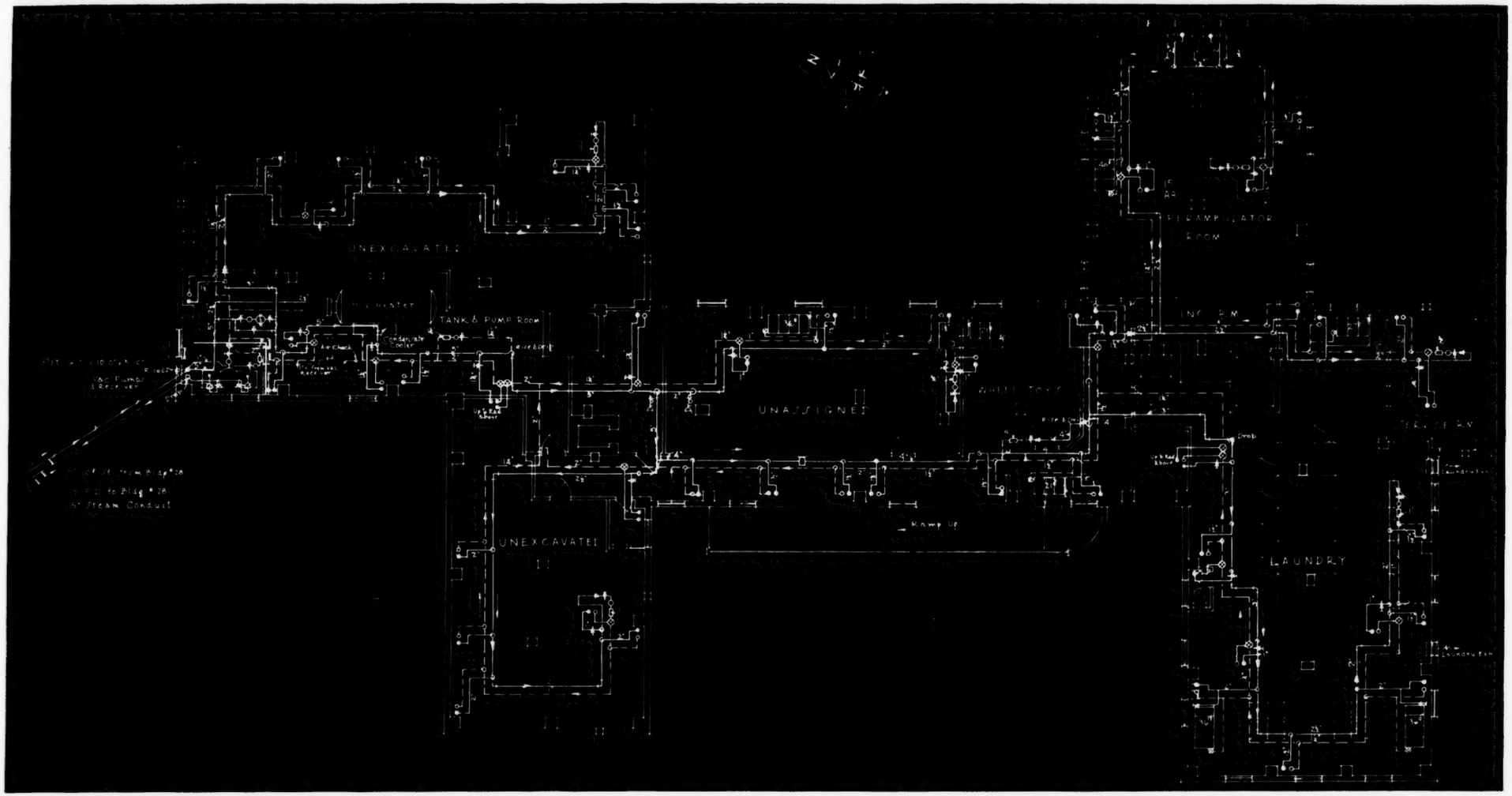


Fig. 3. Boiler room cellar of building No. 24 showing plan of heating mains, section No. 3. Eadie, Freund and Campbell, consulting engineers.

Boiler Room from which the group is supplied. There will also be a hot water storage heater and a condensate cooler located in a Pump Room in the cellar of each building excepting the store buildings. The vacuum return receiver for the building together with duplicate vacuum pumps and controls will also be located in each Pump Room. In the store buildings any provision for hot water, if desired, must be made by the store tenant.

The boilers will be operated at a gage pressure of approximately 10 lb per sq in. and steam at this pressure, less the drop in the lines, will be delivered to the heating system control valve and to the hot water heater in each building. In each group the condensate from the heating system and hot water heater of each building will be discharged by the building vacuum pump into a common pump discharge line emptying into a receiver located in the Boiler Room of the group, from which it will be returned to the boilers by means of a duplicate set of boiler feed pumps. There will thus be a total of 38 vacuum pumping sets and 6 boiler feed pumping sets for the entire project. The size of the heating system piping has been based upon a maximum drop of 1 lb between the control valve and the most distant radiator valve.

Between buildings the 10 lb pressure steam supply main and the condensate return main will be carried in Therm-O-Tile steam conduits, which will be laid in trenches and suitably under-drained. In these trenches the conduits containing the cables for electric control of the heating systems will also be laid. Where these steam conduits pass under streets or driveways they will be protected by reinforced concrete casings.

The amount of equivalent direct radiation to be supplied from each boiler plant is given in Table 1. The E.D.R. for building heating includes radiators, exposed supply and return risers and exposed run-outs between the same and the radiators. In establishing boiler sizes 10% was added to the total figures given below to provide for losses in mains and run-outs to risers. The hot water heating load has been established on the basis of a 110F rise in temperature and supplying approximately 12 gal per hr per apartment.

TABLE 1.—E.D.R. CONNECTED TO EACH BOILER PLANT

Boiler Plant		Building Heating	Hot Water Heating	Total	
Section	Bldg. No.	Sq Ft E.D.R.	Sq Ft E.D.R.	Sq Ft E.D.R.	Families
1	7	72,973	34,762	107,735	678
1	11	83,802*	38,126*	121,928*	750
2	15	28,890	12,224	41,114	235
2	22	66,665	29,853	96,518	622
3	29	59,028	23,684	82,712	496
3	35**	75,382	34,876	110,258	720
Totals Project		386,740	173,525	560,265	3,501

*Includes Community Building.
**Includes three (3) buildings in Section Two.

Each of the 6 heating systems will be provided with an independent system of control. It was decided to provide the most suitable type of control system which would afford a continuous and uniform distribution of steam to every radiator in varying amounts governed by the relative outdoor and indoor conditions to produce a maximum of comfort, within the limits of the

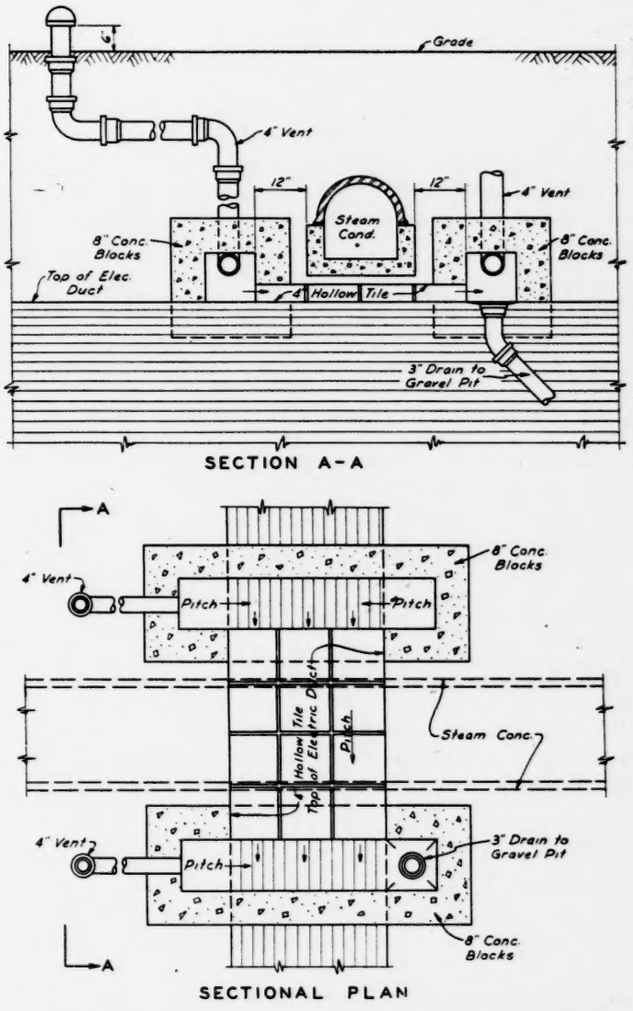


Fig. 4. Plan and section showing method of ventilating 4-inch insulating tiles between the underground steam conduits and the electrical ducts for plans from section No. 3; Eadie, Freund and Campbell, consulting engineers.

funds available for its installation. As the buildings are generally only two rooms deep from outer wall to outer wall and in view of their configuration, it was decided to provide a single point of control for each building, and also that any slight advantage of further zoning would not justify the accompanying increase in the initial cost of the installation.

Dunham sub-atmospheric systems of control will be installed. In each radiator inlet valve union there will be placed a regulating plate with orifice of suitable size to govern the steam flow into the radiator in proportion to its heat output requirement. In the cellar of each building will be located a Heat Balancer. This is an enclosed convector in combination with resistance thermometer coils, which measure the temperature rise through the convector and hence the rate of heat supply to the building. It serves to report electrically the actual heat output of the system in the building to the control panel for the building, which is located in the Boiler Room of the group. On a window located on the north wall of the building containing the Boiler Plant a group of Selectors are mounted, one for each building supplied by the Boiler Plant. The Selectors, which are mounted on the inside surface of the glass, are essentially resistance thermometers and each reports the heat demand caused by outdoor temperature

and wind velocity to the respective control panel. The balancing of the Selector and Heat Balancer reports regulates, by means of a relay, the electric current which operates the motor-driven control valve and thus the amount of steam admitted to the system.

The coil in the water storage heater in each dwelling building will be supplied with steam directly from the 10 lb steam main through a thermostatic temperature regulator with a vacuum-breaker in this connection.

Returns and drips from the heating system in each building will be carried back to a receiver tank located in the Pump Room in the cellar of the building. Into the same receiver will be brought the condensate from the heating coil of the water storage heater and the drips from the 10-lb steam supply line, but these will first pass through the shell of a condensate cooler before being discharged into the receiver. This arrangement will serve a two-fold purpose. It will cool this hotter condensate and reduce loss of heat in the vacuum pump discharge lines which pass underground between buildings and, secondly, utilize this heat instead in pre-heating the domestic water supply of the building. In the buildings containing the boiler plants these condensate coolers will be omitted, for in these cases the condensate from the water storage heater and the high pressure drips are discharged directly into the receiver tank for the boiler feed pumps with practically no attendant heat loss. The condensate coolers will be provided with by-passes. The vapor discharge pipe from the vacuum pump set will be carried into the nearest space in which there is a floor drain.

In many buildings, where cost of excavation limits the height of cellars or basements, the necessary grading of overhead piping results in insufficient headroom and great inconvenience. In order to avoid this condition at Fort Greene Houses and to maintain a minimum headroom of 7 ft below piping, steam supply lines have not been given a continuous pitch through the full length of run, but have been subdivided into sections and dripped at the lowest point of each section. The same procedure has been followed where it would otherwise be necessary to pass under water or drainage pipe lines.

The vacuum or differential pumping set in each building will have duplicate pumps, and will be provided with both vacuum and float control. A Differential Controller will be located in each building to govern the operation of the pump connected both to the supply main and returns main and functioning to maintain the pressure differential between these mains necessary for proper circulation of steam throughout the heating system. This controller starts the pump when the differential falls or disappears and stops it when it is restored. Float control serves to operate the pump for the purpose of discharging the condensate from the receiver tank into the main condensate return running back to the boiler plant. During the non-heating season this pump will serve only to discharge the condensate from the water storage heater coil and for this reason a thermostatic throw-over switch will be installed in the heating supply main of each building about fifty feet beyond the control valve, which will automatically throw the pump on float control only, when steam is shut off from the heating main. There will also be a selector switch located on the controller of the pump with positions marked *Float-On-Vacuum On, Float-Only* and *Continuous*. In either of the first two positions either pump will be on float control and, in the first position, on vacuum control as well, whenever steam reaches the thermostatic throw-over switch. In the third position it will be on manual push-button control only.

The boilers, built by the Oil City Tank and Boiler Company, are of welded steel, fire-box, fire-tube type, of compact design, with tubes arranged for double pass. The number of boilers in each boiler plant and the Steam Heating Boiler Institute ratings (oil-fired) are as shown in Table 2.

TABLE 2.—BOILER DATA

Boiler Plant Building No.	No. of Boilers	Boiler Hp. Each	Total Boiler Hp.	Oil Storage, Gal.
7	4	174	696	20,000
11	4	217	868	25,000
15	3	130	520	12,000
22	4	217	868	25,000
29	4	174	696	20,000
35	4	217	868	25,000
Total	23	...	4,516	127,000

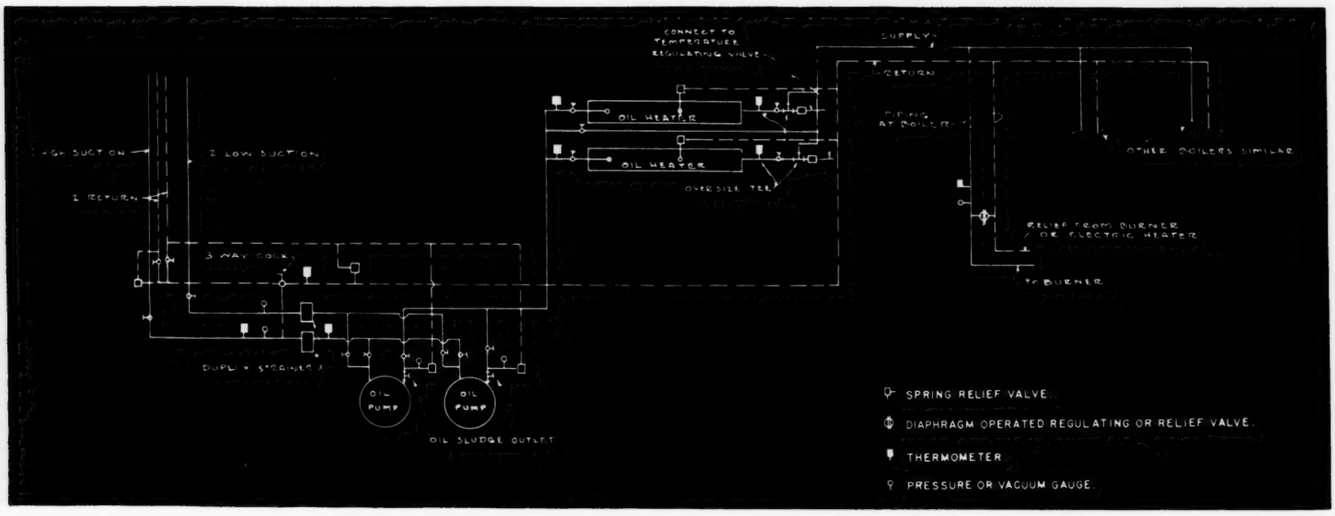


Fig. 5. Diagram of oil piping, not to scale, as used in building 15. Clyde R. Place, consulting engineer.

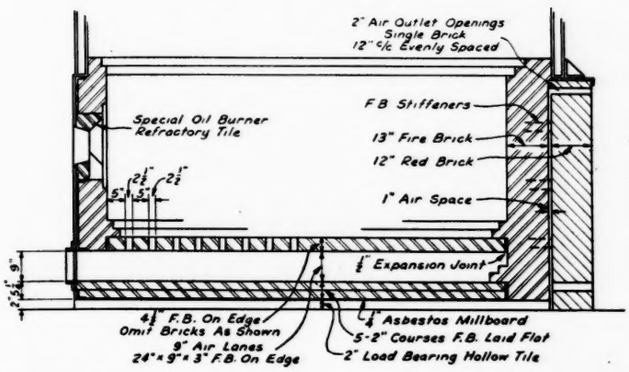


Fig. 6. (Above) Longitudinal section of boiler setting in section No. 3. Eadie, Freund and Campbell, consulting engineers.

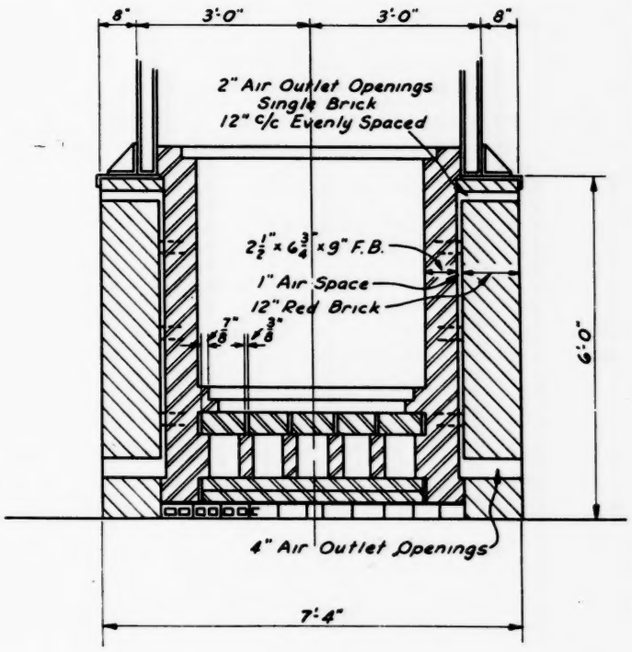


Fig. 7. (At right) Cross section of boiler setting section No. 3.

These boilers will be erected on ventilated brickwork settings 6 ft high and each will be equipped with an oil burner of the direct driven, full automatic, modulating, horizontal, rotary cup type, made by Todd Combustion Equipment, Inc., and designed to burn No. 6 fuel oil. These settings will rest on the flat concrete floors slabs and the furnace floor will be underlaid with a 2 in. layer of hollow terra-cotta tile, covered with asbestos millboard ¼ in. thick and two courses of fire-brick laid flat. Fire-brick will be North American Refractories Company's Crescent H. M. brand.

Natural draft will be obtained by means of brick chimneys built integral with the exterior walls of the buildings and in harmony with the architectural treatment. In the first three stories insulation will be provided in the walls of rooms at which these chimneys occur so as to avoid excessive transmission of heat into such rooms. In the wall of each chimney in the Boiler Room an automatic barometric damper (draft adjuster) will be provided. Smoke breeching connections have been arranged to be as short as conditions will permit. A hand damper will be provided in each boiler uptake connection, which will close off only 80% of the area of the uptake and the damper will be padlocked in the open position. The chimneys are of size to permit the use of coal as fuel, if this becomes necessary in the future.

In each Boiler Room smoke alarm and smoke indicating equipment will be provided, including a single audible and visual alarm for the entire boiler plant and an individual visual indicator for each of the boilers. Flue gas thermometers indicating the temperature in each boiler uptake will be also provided, as will CO_2 sampling equipment. A portable flue gas analyzing outfit will be kept in readiness in the management office.

It is intended that, in each boiler plant, with one boiler out of service for repairs, the remaining boilers will deliver the maximum load requirements operating at 150% of the S.H.B.I. ratings.

Each boiler plant will be provided with a fuel oil storage tank buried underground outside of the building, convenient for filling from the driveway and provided with a manhole for access. The sizes of these tanks are listed in Table 2.

Each boiler plant will be provided with duplicate electric motor driven Kraissl oil pumps and duplicate Vulcan steam-oil heaters equipped with temperature control, relief valves on the oil lines, and all necessary controls and appurtenances in connection with the oil burner installation. A high suction and a low suction oil line will be provided and so connected to the suction of the pumps that accumulations of sludge or water in the bottom of the tank can be removed without interrupting operation of the burners. A return line and an auxiliary return line will be installed, the main return entering the oil tank at the suction end with the auxiliary return connected to a submerged pipe carried just above the bottom of the tank to the opposite end. The purpose of this arrangement is to prevent the accumulation of cold oil in part of the tank and to minimize the formation of sludge. By means of one of two 3-way valves the operator can return oil to the tank through either of these lines as desired, and by means of the other send the return oil directly to the pump suction when desiring to produce rapid circulation of oil through the heater. An electric oil heater will be provided on each oil burner for use in starting up.

Necessary thermometers, pressure and draft gages and foam type fire extinguishers will be installed. In addition to the main blow-off and surface blow-off connections from each boiler, special connections for draining the water-legs will be made to the blow-off header.

In each Boiler Room there will be installed complete soot blower equipment as made by Diamond Power Specialty Corporation, including a rotary type cleaner affixed to each boiler and supplied with compressed air from an American Air Compressor Corporation's two-stage V-type compressor and air receiver tank.

Duplicate boiler feed pumps and a receiver from

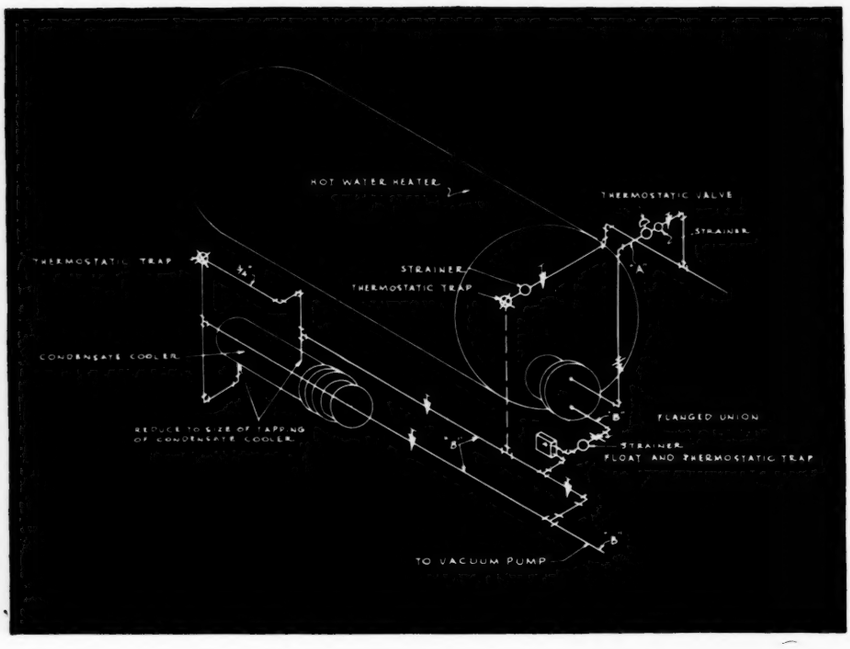


Fig. 8. Detail of hot water connections as used in the buildings in section No. 1. The size of A range from 2 to 3 inches and of B from 3 to 5 inches depending on the size of the building. Syska & Hennessy, consulting engineers.

which these draw will be installed in each Boiler Room. Into this receiver will discharge the condensate pumped back by the vacuum pumps in the buildings supplied by this boiler plant, together with the condensate from the water storage heater and *high* pressure drips in the building in which boiler plant is located. Each boiler will be provided with a boiler feed water regulator, which will also have an auxiliary switch. These auxiliary switches will be wired in parallel so that the boiler feed pump will operate as long as any boiler feed regulating valve is open, but will be shut down when boiler feed regulating valves on all boilers are closed. The float switch controlled by the float in the receiver will be in series with these auxiliary switches and the float will be set at the lowest possible water level at which the pump can operate without drawing air into the suction line of the pump. With this arrangement the boiler feed pump will operate as long as there is sufficient quantity of condensate in the receiver and any boiler is demanding water. If the condition of inadequate supply of condensate for the boiler demand were to occur, cold make-up water would be admitted to the boilers at the receiver.

General exhaust ventilation for the boiler rooms will be provided by means of multi-blade fans. Where hung ceilings occur, air will be also exhausted from the space above the same and separate volume dampers will be provided. Six changes per hour based on gross volume of the boiler room space have been allowed. Admission of fresh air will be secured through louvered openings in the walls.

Provision has been made in the structures to permit removal of boilers in the future and introduction of new boilers.

FORT GREENE HOUSES

Section One: Architects, W. K. Harrison, J. A. Fouilhoux, Rosario Candela and Albert Mayer. Mechanical, sanitary and electrical installations designed by Syska and Hennessy, Consulting Engineers.

Section Two: Architects, Ely Jacques Kahn, William I. Hohauser and Ethan Allen Dennison. Mechanical, sanitary and electrical installations designed by Clyde R. Place, Consulting Engineer.

Section Three: Architects, Clarence S. Stein, Charles Butler, Henry S. Churchill and Robert D. Kohn. Mechanical, sanitary and electrical installations designed by Eadie, Freund and Campbell, Consulting Engineers.

For the New York City Housing Authority, William F. R. Ballard served as Consulting Architect, with Sullivan A. S. Patorno advising on matters pertaining to the mechanical, sanitary and electrical installations, and John P. Riley was Chief Engineer. George R. Genung, in charge of the Management Division of the Authority, contributed the results of his experience in managing existing housing projects. A. Carl Stelling was Landscape Architect, Ralph Eberlin, Civil Engineer and Fred N. Severud, Structural Engineer for the project. By means of a series of conferences throughout the planning period, coordination and harmony of design were secured.

Installation of the heating and ventilating and plumbing made by Jarcho Bros., Inc. D. M. W. Contracting Co., Inc., is the general contractor for the superstructures.

The Paradox of Acclimatization

By F. W. HUTCHINSON†

Although we infrequently think in such terms, almost every time we pass from the outdoors to an air cooled or heated building, or vice-versa, our bodies must become acclimatized. The author discusses in engineering, rather than physiological, terms the process of adjustment of the human body to the changed condition.

AS a thermal machine, the human body is equipped with a surprising number of automatic controls. Body temperature is maintained at 98.6F regardless of normal changes in load or in external conditions; the rate of energy dissipation is regulated by automatic adjustment of the volume of blood flowing through the surface capillaries. Extreme environmental conditions induce physiological reactions, which act, in effect, as safety valves and, for added protection, are beyond the control of the *operator*. Thus when the outside temperature rises and heat loss by the usual mechanisms is dangerously reduced, the body's equivalent of a high temperature control—the sweat gland system—goes into operation, floods the skin surface with moisture, increases the evaporation loss and restores equilibrium conditions. At the other extreme, with low environmental conditions, nature has provided emergency control in the form of shivering—a high frequency mechanical vibration of the body which requires as much muscular work as would moderate exercise and hence increases the metabolism of an individual who, through carelessness or incapacity, fails to heed the initial evidence of excessive body heat loss; shivering is a form of involuntary exercise.

The condition commonly described as thirst is almost exactly comparable to the simple low-level control that is standard equipment on modern boilers. Striking demonstration of this fact was realized when Bernard in 1856 carried out his classic experiment. By providing a direct outlet from a horse's stomach, water was removed as rapidly as it entered and the horse's thirst remained unquenchable. Until that time many physiologists had considered thirst as a local condition resulting from dryness of the throat and mouth, but Bernard's experiment demonstrated clearly that it is an indication of the fluid balance in the body and is a psychological and physiological signal actuated by changes in the pressure, volume and concentration of body fluids. As will be shown later, this is one of the many automatic controls which undergo a resetting as a result of acclimatization effects.

Acclimatization and Shock

Each of the physiological controls described above is a device for maintaining or restoring a given set of equilibrium conditions in the body or at its surface. They are operative in response to changes of internal or external conditions which represent transitory departures from a fixed mean condition. When permanent or long period departures occur, strain imposed on the regulatory mechanisms becomes excessive and nature arranges a secondary response which brings about a re-adjustment of the *control point*. This latter effect is known as acclimatization—a varying of *normal* with environmental changes due to climate, as contrasted with brief departures from normal due to environmental changes caused by weather.

Similar to acclimatization in effect, but different in origin, is the condition of shock which occurs on passing from a conditioned to a non-conditioned environment. The distinction between shock and acclimatization is that the former occurs in the relatively brief interval preceding a return to the original equilibrium conditions while the latter occurs in the extended period during which the body alters its condition of optimum comfort. In each case the severity of the discomfort, or health hazard, depends on the time required for restoration to control conditions and is therefore partially determined by the lag or thermal inertia of the body.

Specific Heat and Body Mass

Since the body consists largely of water its specific heat closely approaches unity; the necessary heat flow to or from storage in the tissues in order to vary the temperature is consequently rather great and, as a corollary, the time needed to accomplish an appreciable temperature rise is therefore much greater than would be the case if the specific heat were lower. This is, of course, a decided advantage as the effects of exposure to extreme conditions would otherwise be disastrous. An average man dressed in such a manner that body heat could not be lost would suffer a temperature rise of approximately 2½F in one hour; if, however, the specific heat of man were that of gold the rate of temperature rise under similar insulated conditions would be 75F per hour. Thus a high specific heat is advantageous in that it permits a greater safety or overload factor, but is undesirable because of the decreased sensitivity resulting from smaller temperature variation.

The effect of lag increases with body size; Bernard has shown that the heat regulating mechanism in animals operates with an effectiveness which varies inversely as mass. This relationship suggests to the air conditioning engineer the possibility that one factor responsible for extinction of such large prehistoric animals as the dinosaur may have been failure to attain acclimatization in a rapidly changing climate.

Cooling Power and Feeling of Warmth

Temperature, humidity, air motion and radiant energy are the determining factors in establishing the cooling power of the atmosphere. Aside from phys-

†Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif.

ical differences due to food, sex, age, health and individual idiosyncracy, the cooling power plus the effects of shock and acclimatization determine the feeling of warmth. Fig. 1 shows curves for cooling power (solid line) and feeling of warmth (dotted line) plotted against the time of occupancy. Starting with an occupant who has been in an environment for 20 hours, the warmth and cooling power curves are superimposed. At time 22, the occupant moves to an environment having a lesser cooling power and experiences a feeling of warmth which normally would be associated with a cooling power even less than that actually operative. Over a period of hours, roughly from time 22 to time 24, the sensation of warmth subsides to a value corresponding to the actual cooling power. During this transient period the area between the two curves is a quantitative indication of the extra discomfort resulting from shock effects.

When equilibrium has again been realized, allow the occupant to return to the original room. His feeling of warmth now drops to a value lower than that corresponding to the actual cooling power and, over a period of hours, it slowly returns to the equilibrium value. The area between the curves now represents added discomfort due to coldness experienced because of shock.

From the above example it is evident that the feeling of warmth varies more rapidly than does cooling power and exaggerates the effect of a change in environmental conditions. Fig. 2 illustrates this condition for an environment in which conditions are constantly changing (as the outside atmosphere). The curve for feeling of warmth lags that for cooling power and has a greater amplitude.

These drawings illustrate the effect of the transient period during which the physiological control system is restoring equilibrium conditions. The time required for the skin temperature to become adapted to sudden changes in cooling power is not less than 1½ hours and usually closer to 3 hours.

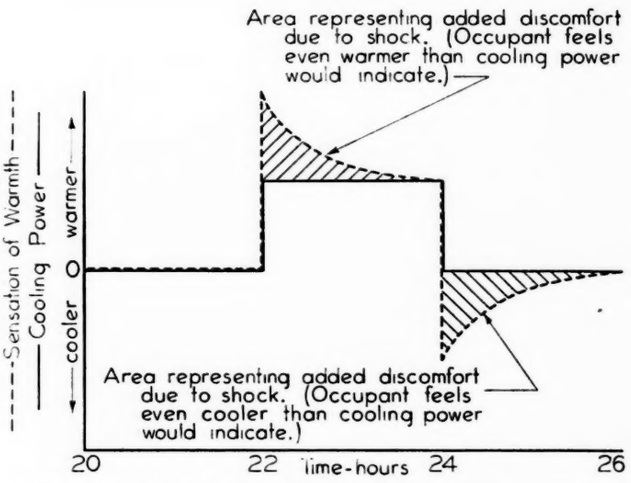


Fig. 1. Shock curves for cooling power and warmth.

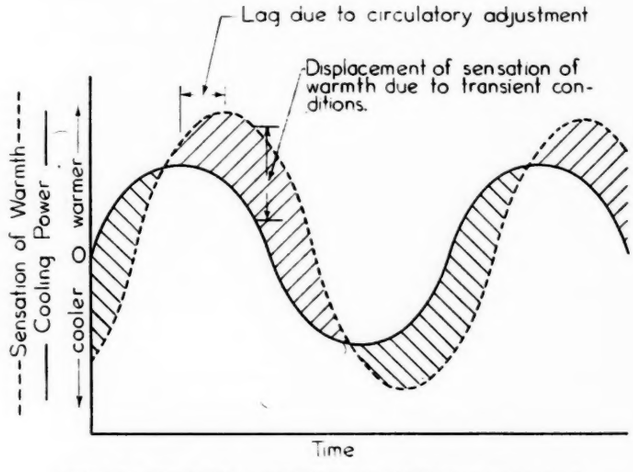


Fig. 2. Periodic variation of cooling power and sensation of warmth.

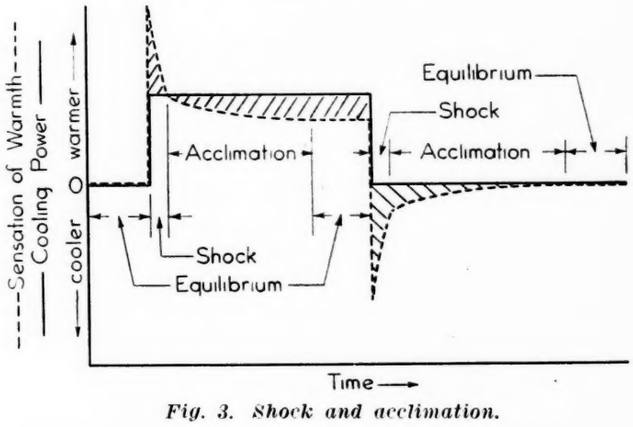


Fig. 3. Shock and acclimation.

Shock and Health

The effect on health of transient effects has been the subject of numerous investigations and, in some respects, is now clear. Many authorities now believe that the chilling effect which accompanies transition to or from extreme atmospheric conditions may be a major factor in the causation of disease. The British Industrial Fatigue Board has compiled a number of tables showing the comparative sickness and mortality among workers exposed to different conditions; from their data the hazard associated with temperature change exceeds greatly that due to consistent exposure to high temperature. In the iron and steel industries the custom is for workers to alternately labor and rest for short time intervals (usually 20 minutes); for these industries a marked increase in the incidence of respiratory disorders is observed over that found among tin plate workers who are subject to temperatures of equal severity, but who work continuously. Additional confirmation of this effect is seen in the fact that puddlers in steel mills who are exposed to the most severe temperature fluctuations show over 20% more sickness than is the average for all steel workers. Substantiation of a different kind can be obtained from the work of Mills who lays great stress on the neurotic effects of weather changes and has succeeded in establishing a correlation between changes in atmospheric conditions and suicide. He concludes that drops in temperature or rises in barometric pressure are accompanied by a feeling of exhilaration while changes in the reverse direction induce irritation and mental depression. With air conditioning there is a chilling effect in winter when leaving the conditioned space and a similar chilling effect in summer when entering it. From the present

inadequate data the only conclusion which can be drawn is that the reduction of extreme temperatures which air conditioning makes possible *may* lead to a reduction of functional diseases while the added shock *may* lead to an increase in infectious diseases; the net effect is at present indeterminate.

Seasonal Acclimatization

In contrast to the short-period shock effects illustrated in Figs. 1 and 2, true acclimatization appears as a slow re-positioning of the cooling power corresponding to a feeling of optimum warmth. Extensive data collected in South African diamond mines indicate that a three-day period is required for adjustment of the miner to hot and moist underground conditions. Reports from mines in India suggest that acclimated native miners may actually prefer temperatures of 85 to 90F and in some cases it has been reported that natives are known to do sustained work over a period of months at a wet-bulb temperature of 99F. The latter report prompts reference to Henry David Thoreau's question, "With an external heat greater than our own internal, may not cookery properly be said to begin?"

The effect of acclimatization is illustrated in Fig. 3 which represents the same environments as Fig. 1, but with extended periods of occupancy. Considering the initial environment as one of optimum comfort, the effect on the occupant of transferring to an uncomfortably warm condition is seen to be first an experience of an exaggerated feeling of warmth which in a few hours subsides to the condition of discomfort normally associated with the actual cooling power; this far, Fig. 3 duplicates the conditions of Fig. 1. Now, however, as the occupant remains in the warm environment, an adjustment occurs of the physiological *base point* and—as shown in the chart—the sensation of warmth corresponding to the fixed cooling power slowly drops until it reaches a new acclimated value. The effect of this change is equivalent to an upward displacement of the cooling power corresponding to an optimum feeling of warmth.

Suppose now that the occupant, when acclimated to the warmer room, then returns to the environment in which, originally, he realized comfort. As shown in Fig. 3 the first reaction would be one of severe overcooling followed by a brief period of circulatory adjustment after which, with physiological equilibrium, the occupant would still be uncomfortably cool. Subsequently and over an extended period, re-acclimatization would occur with a gradual rise of the feeling of warmth until finally the original *base point* would be regained and comfort realized.

Physiologically, acclimatization manifests itself principally in an increased activity of the sweat glands and a change in concentration of salt in the moisture loss. The unacclimated man loses weight rapidly because his sweat glands discharge a solution with a salt concentration approaching that of normal body cell fluids. As he becomes adapted to the warmer conditions the concentration decreases, thirst becomes important and he automatically replenishes the fluid loss without significant change in body weight. Further, the time interval between exposure to unusually warm conditions and the first appearance of sensible perspiration is less in summer (acclimated conditions) than in winter. Other evidences of physiological readjustment —as changes in pulse, skin temperature, etc.—have been reported by various investigators.

Summary

Acclimatizing effects are an aggravating influence. Because of them a change in environmental conditions toward cool always feels colder and a change toward warm always feels warmer. It is paradoxical that the one device which nature gave man as a protection against the effects of atmospheric extreme should be the most important obstacle in the path of the engineer who seeks to assist man by eliminating those extremes. If it were not for the protection which acclimatization affords, the discomfort caused by summer temperature would be greater, but if it were not for acclimatization the shock attendant upon the use of summer cooling would not be so great. The same is true for winter conditions and the heating systems which alleviate them.

Two Stratospheres in Middle Latitudes

The atmosphere has an attic.

Over the temperate regions of the earth is a "pseudo-stratosphere," concludes Dr. Henryk Arctowski, Polish meteorologist, now conducting investigations at the Smithsonian Institution, from a study of radio sounding records of the U. S. Weather Bureau.

A roof of the world long has been recognized. For a certain distance, depending on latitude, temperature decreases with altitude. With greater heights the decrease stops and it may even become a little warmer. The point where this occurs is known as the tropopause. All the atmosphere above it is the stratosphere, vaguely explored field of the air voyagers of tomorrow and, it generally has been supposed, region of almost perfect calm.

The tropopause, as it long has been known, is highest over the equator. There, at any season, is the coldest spot "on earth." It slopes down, like the roof of a house, to the two poles.

Four years ago the French meteorologist Jaumotte fixed the base level of the tropopause at approximately 18 kilometers above the equatorial regions. This level corresponds, according to Jaumotte, to the level of increase of helium, of ozone, and of the electrical conductivity of the atmosphere—a real, atmospheric roof of the planet.

But the radio soundings show, Dr. Arctowski insists, that in middle latitudes one must admit the existence of two stratospheres. For certain distances the temperature goes down according to schedule, the rate of decrease increasing with altitude. Then there is a narrow region with little or no decrease, after which the decrease sets in again. The middle region might be compared to the world's attic.

PROFITS IN AIR

The Painesville Telegraph

air conditions its windowless plant—the first newspaper building of this kind. Of particular interest in this description is the method of zone control and the solution of The Case of the Leaking Ducts.

By LESTER T. AVERY

Here shall the Press the People's right maintain,
Unawed by influence and unbribed by gain;
Here Patriot Truth her glorious precepts draw,
Pledged to Religion, Liberty, and Law.

THIS motto of the *Salem Register,* adopted in 1802, could have been used equally well to describe the *Painesville Telegraph,* a Lake County, Ohio, institution since its founding in 1822. This newspaper was one of the important influences in the winning of the West, particularly the part of Northern Ohio known as the Western Reserve. In those early days Painesville and Cleveland were equal in population and importance, and it was chiefly the accident of terminating the Ohio Canal in the Cuyahoga River at Cleveland, instead of in the Grand River at Painesville, that gave Cleveland the impetus to grow vigorously, while Painesville pursued a more leisurely and contented life.

Through all these years the *Painesville Telegraph* held its own place in the community, accompanying the people of Lake County to and from half a dozen wars, tending their births, weddings, and buryings; and by its precept showing how to live the vigorous life in a vigorous land. When the time came, in 1939, to build a new and better home, C. A. Rowley, the owner, and H. H. Henes, the manager, agreed with their architects, J. Wallace Green and Hays, Simpson and Hunsicker, to make it a completely air conditioned, windowless building.

This newspaper that had such a glorious past was not afraid to go modern in the new building and equipment. In the new structure the Painesville people find the same informal friendly atmosphere as they have always found when they came in to call on the *Telegraph,* but something new has been added. The atmosphere is completely conditioned so that temperature, humidity, and ventilation are equally friendly. The *Painesville Telegraph* building was one of the first completely conditioned windowless newspaper buildings in the United States, and it has blazed a trail in this respect, even as the original paper blazed its trail in the early nineteenth century.

And will the news be any better because it comes out of this modern, efficient plant? Mr. Henes, managing editor, would say he doesn't make the news, so you'll have to take it as it comes whether you like it or not. But from the standpoint of economical operation, efficiency of employees, quality of makeup and respect of subscribers and advertisers, there is no question about the *Telegraph* being better published.

From an air conditioning standpoint, the installation had its peculiarities and lessons to be learned. Fig. 1 is a picture of West front and South side—clear glass show windows and glass block walls. Fig. 2 is a plan of the first floor with five zones separately controlled with auxiliary automatic control in the executive office. Fig 5 is a view of the mechanical department, Northeast corner, and Fig. 3 shows the editorial offices in the Southeast corner. Zones 1 and 2, respectively. The basement has three zones, one of which is for paper storage.

For those interested in the zone system of control, the following explanation is given with the idea of pointing out the difficulties and how they were handled.

Because the load for heating and cooling varied tremendously in each zone, both in relation to other zones and in relation to itself under different conditions, the mixing damper system was selected as being efficient and sufficiently flexible. With this scheme, see Fig. 4, outside air and recirculated air are mixed and filtered and drawn through preheating and precooling coils. There are no radiators in the offices, all heating being done by the zone control system.

HOW INDUSTRIAL PLANTS PROMOTE PROCESSES AND PROFITS BY SCIENTIFIC CONTROL OF ATMOSPHERIC CONDITIONS

Precooling and preheating fixes the mixed air condition at thermostatic set point of 69F. The discharge from the fan goes to reheating and recooling coils in what is called a hot and cold deck discharge chamber. The several zone ducts (eight in all) are connected to these hot and cold decks with automatic dampers in each so that the zone thermostat can select *how much* cold air to mix with the bypassed, precooled air to hold the zone at required temperature in the cooling cycle. Similarly, the zone thermostat selects how much hot air is mixed with the bypassed, preheated, relatively cool air to hold the desired warmth in the heating cycle. An indication of the flexibility of this scheme is noticed in the air temperatures existing in the several supply ducts to hold the similar zone temperatures. For example, on a warm summer day the coolest zone will require air at 74F at the *same* time the warmest zone is getting air at 62F. And as the sun goes around the building or the presses are started and stopped, or other local conditions in any one zone change, the delivered air may vary 10F in 24 hours for supply to that zone. Newspapers run or are held ready to run 24 hours a day and the *Painesville Telegraph* is on the job all the time.

The cold deck is planned at 45F where the air leaves the recooling coil in summer. The hot deck is set at 68F to 100F. It is very easy to hold the hot deck by using a thermostat in it, and throttling the steam flow through an automatic valve. That was effectively done. But where would you suggest installing the control thermostat for cooling on the cold deck to hold say 45F? The first thought is the same as for heating, right in the cold deck, but the cooling in this case was done by direct expansion refrigerant, using a Worthington-Carbondale 50-ton, Freon-12 condensing unit with 50% load control. The thermostat in the cold deck caused the machine to cycle as the temperature change was wide and rapid with the machine operation. Separate thermostats on the expansion valves did not help.

PROFITS IN AIR

ONE OF A SERIES OF ARTICLES SHOWING HOW PLANTS PROMOTE PROCESSES AND PROFITS BY SCIENTIFIC CONTROL OF AIR CONDITIONS

Fig. 1. The completely air conditioned plant and offices of the Painesville Telegraph which is divided into five zones, separately controlled, with auxiliary control in the executive offices.

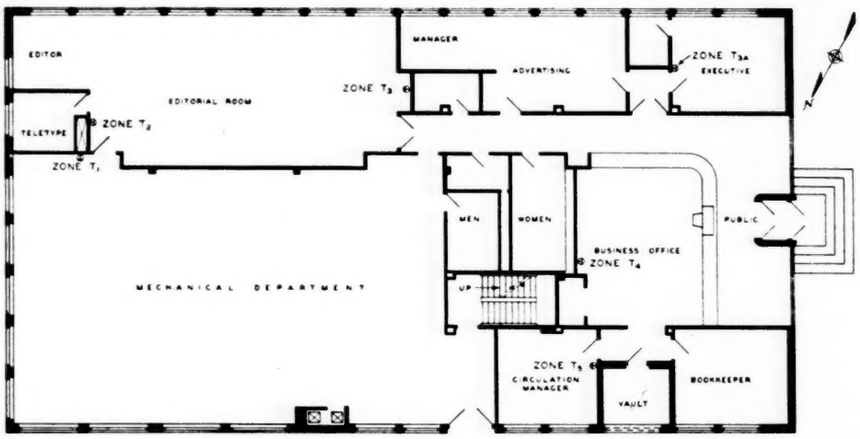


Fig. 2. Plan of the first floor, Painesville Telegraph plant, showing locations of the thermostats for the different zones.

The answer was found in putting the machine thermostat in the *return air* duct at the unit. Thus if the *mixed* air return temperature went above the set point of 75F, the thermostat started the refrigerating machine and the conventional Alco thermal valves were set to hold approximately the desired precooling and cold deck temperatures. The load control valves on the machine were operated from suction pressure in the common return from the Aerofin direct expansion, Freon-12 coils. While this control arrangement might be considered too crude, actually it was sufficiently refined to do everything demanded of it, namely, hold the several zones at set points from 76F to 79F in the summer cooling cycle. The hot deck temperature was reset during the winter heating cycle by an outside air master thermostat to vary the hot deck from 68F at 60F outside to 105F at 0F outside. This permitted the extra heating needed in cold weather and prevented overrun of heating in mild weather.

A special economizing system of cooling was incorporated in the Minneapolis-Honeywell pneumatic control system whereby outside air could be used in large quantities for cooling when it was suitable. This was a windowless building, the glass windows and blocks being for light only, so that an exhaust fan was provided which would operate when the extra outside air was being introduced. This cycle was controlled by a thermostat in the outside air to open the maximum outside air damper and close the recirculated air damper and start the exhaust fan when the outside air was above 62F and below 75F. Another thermostat in the outside air cuts out the compressor circuit when the outside air is below the set point of 65F, so that the refrigerating machine cannot fight the heating control if the inside temperatures should so require.

The auxiliary control for the executive office required a stat in the air duct which would say whether the air was to be considered as heating or cooling; that is whether duct air was above or below the room temperature. Having decided this important question, the duct stat permitted the roomstat to take more or less of this air by modulating the volume damper to hold the desired room temperature.

Summer dehumidifying was accomplished with the cooling coils, as the internal moisture load was fairly close in proportion to the cooling load. Individual humidities in zones will not vary greatly as vapor pressures tend to equalize throughout any building with communicating doors. For winter humidifying a steam humidifier was used in the main fan section. As the paper storage rooms need high humidities, as does the press room to prevent static, separate humidistats operate separate steam humidifiers in the ducts leading to these zones.

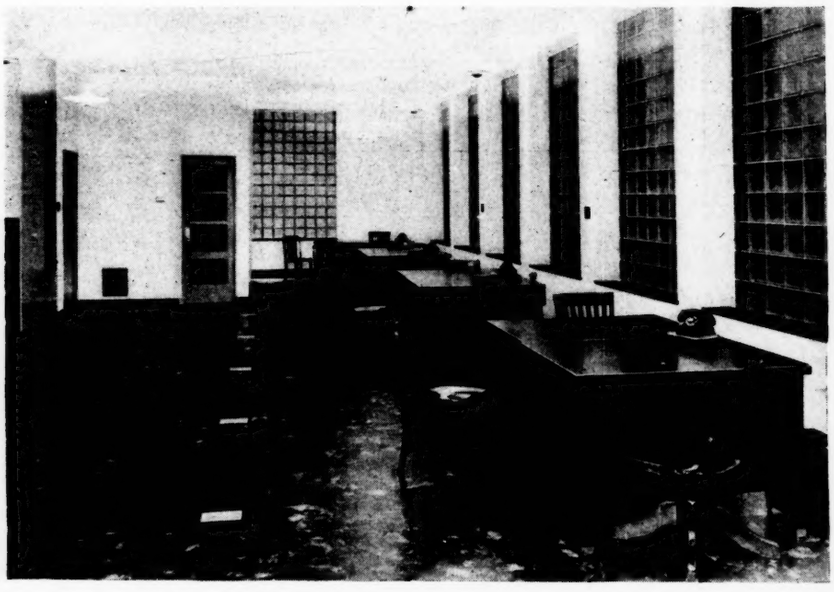


Fig. 3. The editorial room as seen from a point near the thermostat for zone T_3 (see Fig. 2).

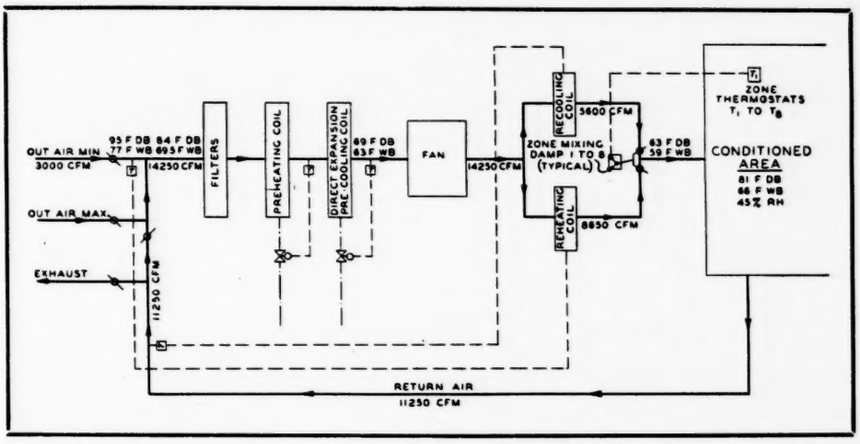


Fig. 4. Flow diagram of the air conditioning system. Summer dehumidifying is accomplished by the cooling coils, the internal moisture load being fairly close in proportion to the cooling load.

The reader who has stuck this far deserves a special reward and here it is, just like the olive at the bottom of the martini. The author has made his share of mistakes and learned things the hard way. It is his conviction that articles of this kind should include a frank discussion of special problems and how they were solved, even mistakes made. In this case, the design contemplated a 450 ft air velocity through the recooling coil, so that a drip pan was planned to carry away condensed moisture. But if all zones were asking for all the cooling they could get, *all* the air would go through the recooling coil, even if only for a short time until the temperatures were brought under control. But the damage was done and a velocity of 700 to 800 ft carried the water right along and the ducts "leaked"! This was not properly analyzed at first and an attempt was made to make the ducts water tight, thereby pushing the water farther and farther away from the mixing chambers and the engine room and out into the press room. The cure—a good three break eliminator section in the cold deck between the coil and mixing dampers. Space had to be made for this afterthought. Eliminators shall be used from here on wherever there is a remote possibility of high velocities through the cooling coils, due to possible variations in air quantities. "Leaking" ducts are not funny.

The refrigerating machine was supplied with a Worthington-Carbondale shower condenser installed on the roof of the building. This condenser was the conventional type, including condensing coil, fan, filter, pump, and casing. Thus the operating cost for cooling was narrowed down to the actual need of power for the compressor and shower condenser and the heating was efficiently controlled to the need of fresh air, using the building's own sources of heat, such as sun effect through the glass, lights, presses, to be supplemented by a stoker-operated Kewanee steam boiler.

John Paul Jones, Cary & Millar were consulting engineers.

When one considers that the reason for any building at all is to keep the outside weather out, it seems consistent to keep the inside the way it is wanted when it can be done so easily. There are many newspaper buildings of the same size that spend more for winter heating alone than does the *Telegraph* for heating *and* cooling. By going all out for air conditioning and permitting the architects to design a building where it could be done economically, and by permitting the engineer to design a system good enough to really *do* the job economically, the *Telegraph* got what it wanted, a truly modern home at a minimum operating cost. The wiseness of this policy will be demonstrated many times in the coming years.

Fig. 5. The mechanical department of the plant as viewed from a point approximately in the center of the drawing Fig. 2.

Dr. SALSBURY'S LABORATORIES

where livestock and poultry vaccines and bacterins are prepared, find air conditioning important in growing and preserving biologicals of many types.

PROFITS IN AIR

ONE OF A SERIES OF ARTICLES SHOWING HOW PLANTS PROMOTE PROCESSES AND PROFITS BY SCIENTIFIC CONTROL OF AIR CONDITIONS

IN the Dr. Salsbury's Laboratories, Charles City, Iowa, offering a nation-wide poultry health service, two rooms used to store packaged biologicals for poultry raising purposes were given special attention as to insulation and cooling. One of these rooms is 8 x 17 ft, the other 12 x 17 ft. In these rooms experts in their line handle and freeze chicken egg embryos prior to the manufacture of fowl pox and laryngotracheitis vaccines. Bacteria and vaccines are manufactured for all of the common ailments of poultry for which an immunity can be stimulated through vaccination. Recently a number of livestock bacterins and vaccines have been added to the line. Keeping such biologicals at the proper low temperature is highly important.

The cooled rooms are insulated with two layers of 2 in. United block-baked corkboard erected in hot asphalt and finished on the walls with portland cement plaster and on the ceiling with emulsified asphalt. The temperature in the rooms is kept at 35F, and the relative huimidity is controlled.

In one room refrigeration is furnished by a 1 hp Frigidaire compressor located in the basement of the

The Dr. Salsbury's Laboratories where poultry biologicals are made and stored.

One of the two large refrigerating rooms for the storage of vaccines and bacterins at Dr. Salsbury's Laboratories, Charles City, Iowa. Vaccines and bacterins are used to stimulate an immunity against infectious diseases of livestock and poultry.

building, with two Peerless coolers to circulate the air across the ceiling. To save space the coolers are installed on the ceiling. The other room is also equipped with a Frigidaire compressor of the same size, with two Frigidaire coolers located in opposite corners of the room at the ceiling.

Two smaller rooms are refrigerated for the storage of biologicals; each of these is 6 x 14 x 10 ft. A 1 hp Frigidaire compressor furnishes the cooling for both of these smaller rooms, with gravity coils installed on the ceiling. A board baffle in the center of the room under the coils distributes the cooled air as it descends to the floor.

Two other rooms in the building are used as incubators, and each of these is equipped with three 500 watt strip heaters located at the floor. In these rooms the organisms are grown in suitable cultural media such as beef broth and various extracts. After the growth is completed, the bacterins are killed through the use of chemicals and the extract is bottled and held ready for distribution under cold storage.

Two New Units—Clo and Met

Are your "clo" and "met" ratings up to par for winter weather?

These strange terms comprise a new technical yardstick which has been created by three American scientists to indicate how much clothing a person will need to adjust to frigid Arctic blasts or tropical heat waves.

The yardstick is expected to have practical implications in showing engineers, physiologists and doctors how rooms should be heated and how people should dress for a variety of weather conditions. It is a systematic standard of describing the necessary heat insulation for the body which protects it from the weather.

Results of this cooperative research are announced by Dr. A. Pharo Gagge, Yale University biophysicist; Dr. Allen C. Burton, University of Toronto biophysicist; and Dr. H. C. Bazett, Professor of Physiology at the University of Pennsylvania, in a recent issue of *Science* magazine.

The *met* represents energy value and varies in absolute amount with the size of the individual. For example, for a man of average size, the met is approximately equal to the heat generated by a 100-watt lamp. One *clo,* on the other hand, is the value of the insulation of a person's everyday clothing. The additional insulation which would be added by top coats and other clothing can be expressed in clo units.

The met and clo units take into account the three factors necessary to maintain the best possible human skin temperature, as follows: 1. the rate of heat production of the body, which is, in turn, dependent on the degree of muscular activity; 2. the insulating value of the clothing; and 3. the environmental temperature.

The met, or energy unit, is defined as 50 calories of skin, or the heat generated by a man in a comfortable sitting position.

The clo, or insulation unit, is the amount of clothing necessary to keep a man comfortable, who is in a resting or sitting condition in a normally ventilated room —temperature of 70F with humidity about 50%.

In describing the ideal clothing which human beings should wear for comfort, the scientists state that "the net efficiency of the human body in performing external work does not exceed 20%. . . . In many cases the efficiency is far less, as in level walking where the heat production rises to several mets without the performance of any external work.

The maximum clothing that can be worn in comfort in a given task may be calculated by engineers who employ this technique. For example, a mountaineer, weighing 160 pounds, surface area 1.9 square meters, climbing at the rate of 1,250 feet per hour, would accomplish a mean rate of work of .75 mets. If other factors such as the use of a windbreaker for 30F are considered, the maximum amount of clothing he should wear would be about 1 clo—the amount he would wear in a normally ventilated room in a sitting or resting position.

ABSTRACTS of Current Papers, Books and Pamphlets

Fuel-Flue Gases

The purpose of this book, which has a rather unusual title, is to bridge the gap between the work of the gas utility chemist and that of the engineering sales force who are looking for application and interpretation of the chemist's findings. The title is intended to convey the concept that widely different properties of gases are definitely inter-related. The book is divided into nine chapters, the first five of which deal with gases (and their constituents) used as fuels; the sixth chapter with the chemistry of the distribution system, and the seventh with atmospheres other than those composed of combustion products. The final chapter deals with the interpretation of the flue gas analysis itself.

Although the book is intended, primarily, for those in the gas industry it contains a great deal of information and data which is of use to heating engineers concerned with gas heating, particularly those engaged in research or testing. One chapter is of rather general interest to all heating and ventilating engineers—chapter 7, on atmospheres other than those for combustion, which gives information on toxicity and properties of gases.

The book is on the same high technical level as previous publications of the Association, all of whose technical publications have been most carefully compiled and edited.

[*"Fuel-Flue Gases." Second Edition. Published by The American Gas Association, 420 Lexington Ave., New York. Cloth bound, 8½ x 11 in.; 198 pages. Price, $2.50.*]

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Oil Burner Service Manual

The need for conserving materials and fuels during war times has resulted in an increased emphasis in the servicing of oil burners not only to make them operate efficiently but also to give them as long a life as possible. Thus, the appearance of this oil burner service manual is especially timely.

According to the author the manual is intended primarily to give to the oil burner dealer and his mechanical staff the information needed for the proper servicing and installation of oil burners. Special emphasis has been given to service and correction of faulty installations and theoretical matters are discussed only when the practical aspects will be incomplete without them.

The book is based on instruction manuals of the manufacturers of various types of oil burners and accessories. These instructions are amplified by numerous practical pointers from men engaged in installation service. Domestic, commercial, and industrial oil burners are described.

[*"Oil Burner Service Manual," by Kalman Steiner and Fred Ravnsbeck. Published by the McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Cloth Bound; 6 x 9 in.; 365 pages. Price, $4.*]

Chemical Engineering Handbook

As American war efforts increase, more and more heating and air conditioning engineers are turning their attention from comfort to industrial applications of heating and air conditioning. This changing interest brings up numerous new problems and the need for information on industrial processes.

An excellent source for much of the information needed for this type of work is the recently published second edition of Chemical Engineers' Handbook. This book contains a surprising amount of information which will interest heating and air conditioning engineers and which would be difficult to find in any other single source.

The book is made up of twenty-nine sections at least ten of which should be of considerable interest to heating and air conditioning engineers. These ten sections are entitled, Flow of Fluids; Heat Transmission; Evaporation; Humidification, Dehumidification, and Cooling Towers and Spray Ponds; Gas Absorption and Solvent Extraction; Adsorption; Drying; Fuels; Power Generation and Mechanical Power Transmission, and Refrigeration.

[*"Chemical Engineers' Handbook," edited by John H. Perry, Ph.D., second edition. Published by McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Flexible binding; 5 x 7¼ in.; 3047 pages. Price, $10.00.*]

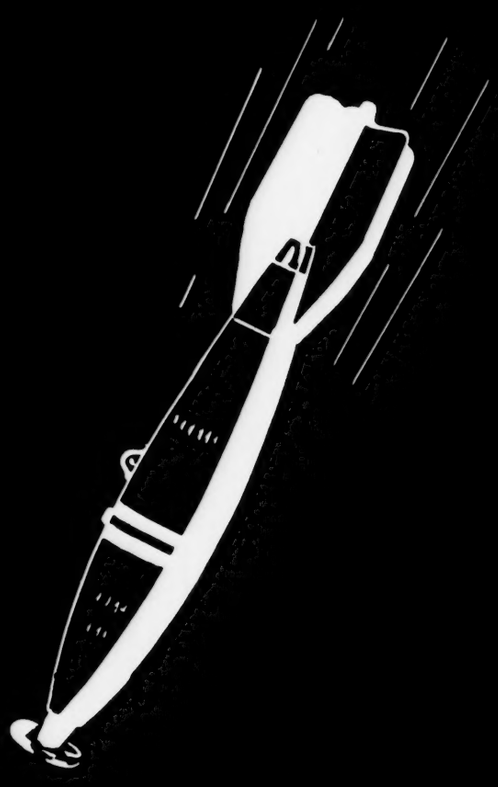
BRIEF REVIEWS

HANDBOOK OF CHEMISTRY AND PHYSICS. In this 25th edition of this well known handbook of chemistry and physics numerous changes have been made to bring the book up to date with the findings of current research work. The book is divided into five sections which include mathematical tables, properties of matter, general chemical tables, a section devoted to heat and hygrometry, sound, electricity, magnetism and light, and a section made up of quantities and units, conversion tables and miscellaneous tables. [*"Handbook of Chemistry and Physics," 25th edition. Published by The Chemical Rubber Company, 2310 Superior Avenue, Cleveland, Ohio. Flexible binding; 5 x 7¼ in.; 2521 pages. Price, $3.50.*]

HEATING. A booklet prepared for the building owner and devoted to information for the layman on cost, maintenance, modernizing and similar phases of building heating. The booklet is the third in a series of building heating booklets for the layman. Titles of the first two of the series are Furnace Heating Guide and Boiler Heating Guide. [*"Building Heating Guide," by K. C. Richmond, editor of Coal-Heat. 47 pages; paper cover; 4 x 8¾ in. Available from Coal-Heat Magazine, 20 W. Jackson Blvd., Chicago.*]

Publications listed under Brief Reviews are not available through HEATING AND VENTILATING but must be obtained from the publisher listed.

VENTILATION AND HEATING OF
AIR RAID SHELTERS



HEATING AND VENTILATING'S REFERENCE SECTION

3

VENTILATION OF AIR RAID S

Air raids by both sides in the present war have been, almost entirely, those involving the dropping of explosive and incendiary bombs. Gas warfare, although not yet employed, except in China, may, however, be resorted to at any time, and consequently it is desirable that information be available for protection against chemical warfare, as well as against explosives.

It is obvious that the heating and ventilating of air raid shelters include the taking into account of odors, vitiation of oxygen and increase of carbon dioxide, temperatures and heat conductivity of the ground, build up of heat in the structure, leakproofing against gas entrance, and other considerations. Many of these considerations are ones with which most of us heating and ventilating engineers are none too familiar, since the conditions are most unusual and the objectives unique.

With the problem an unusual one, it necessarily follows that the data and other information needed by the engineer are scattered or, perhaps, even entirely unavailable. Under such circumstances much time can be lost in assembling this information. This Reference Section is an attempt to collect as much of the scattered basic data as are available so that the design engineer need not spend valuable time in preliminary work.

BOMBS AND SHELTERS

By F. F. KRAVATH†

The purpose of this article is to review the types of air-raid shelters available, types and characteristics of the bombs against which protection is sought (as well as the gases liberated by some of these bombs), and the equipment necessary for the adequate ventilation of these shelters. First, however, a review of the subject of air vitiation, the underlying consideration in ventilation of air-raid shelters, will be given.

When a number of people are confined to a limited, enclosed space, the air undergoes certain physical and chemical changes brought about by the occupants themselves. The oxygen content is somewhat reduced and the carbon dioxide slightly increased by the respiratory processes. Organic matter, which is usually perceived as odors, comes from the nose, mouth, skin and clothing. The temperature of the air is increased by the metabolic processes, and the humidity raised by the moisture emitted from the skin and lungs. Expired and transpired air is odorous, offensive, and capable of producing loss of appetite and disinclination for physical activity. These physiological reasons call for the introduction of a certain minimum amount of clean, outdoor air to dilute the odoriferous matter to a concentration which is not objectionable. In ordinary enclosures, there is enough infiltration of air, due to leakage, to supply this deficiency. In gas-tight shelters, there is little appreciable leakage, what there is being outward leakage rather than inward. This outward leakage is absolutely necessary to fulfill the functions of a real protective shelter.

While carbon-dioxide is not generally fatal unless present in such high concentration as 800 to 1000 parts per 10,000 parts of air, there is no design significance attached to such figures, since extreme nausea and vomiting would occur long before such a figure is reached. The amount of fresh air necessary in shelters is influenced in great part by the size and shape of the shelter, number of people accommodated within, age and physical well-being of the occupants, their degree of cleanliness, amount and type of air circulation available, and the presence or absence of dehumidifying and washing equipment. Design should be based on the amount of fresh air necessary to remove objectionable body odors. The accompanying drawing, Fig. 1, a liberal interpretation of Yaglou's work on this subject in a Harvard-ASHVE project, indicates the fresh air requirements for various types of occupants under varying conditions from the standpoint of odor.

As can be seen from the chart a greater amount of fresh air per person is necessary in small enclosures than in large. Generally, the quantity

Fig. 1. Fresh air required per person to overcome odors. These curves are a liberal interpretation of the work of Yaglou on this subject.

†Lieutenant (JG), Civil Engineer Corps, United States Naval Reserve.

SHELTERS

of air required varies inversely as the social-economic class of the individual, due apparently, to relative frequencies of bathing. For example, a laborer will require considerably more fresh air than the average man engaged in office work, and this is true regardless of the season of the year or size of the enclosure. Grade school children in slum areas require almost twice as much fresh air as do those in neighborhoods where the income is greater. Yaglou showed that there is a decided reduction in fresh air requirements for all classes during a heating season if the air is properly humidified and circulated, while during the summer season, with cooling, dehumidification and adequate circulation, the necessary fresh air is reduced to an extremely low figure, being somewhat less than 4 cfm per person. Note that children require more fresh air than adults.

Almost as important as air quality and quantity is the effective temperature of the air, effective temperature being an empirically determined index of the degree of warmth perceived on exposure to different combinations of temperature, humidity, and air movement. Sensations of warmth or cold depend, not only on the temperature of the surrounding air as registered by a dry-bulb thermometer, but also upon the temperature indicated by a wet-bulb thermometer. Dry air at a relatively high temperature may feel cooler than air of considerably lower temperature with a high moisture content. Air motion makes any moderate condition feel cooler. On the other hand, in cold environments an increase in humidity produces a cooler sensation. The dividing line at which humidity has no effect upon warmth varies with the air velocity and is about 46F for still air and about 51, 56, and 59F for air velocities of 100, 300, and 500 fpm respectively. Under ordinary conditions, the human body temperature is maintained at a normal level of about 98.6F. The heat resulting from the combustion of food within the body is constantly lost by radiation, conduction and evaporation. As the air temperature rises up to 80F, metabolism, or internal heat production, decreases slightly. This is balanced by an increased peripheral circulation, skin temperature and heat loss. If this method of losing bodily heat is insufficient, the stimulus is extended to the sweat glands which al-

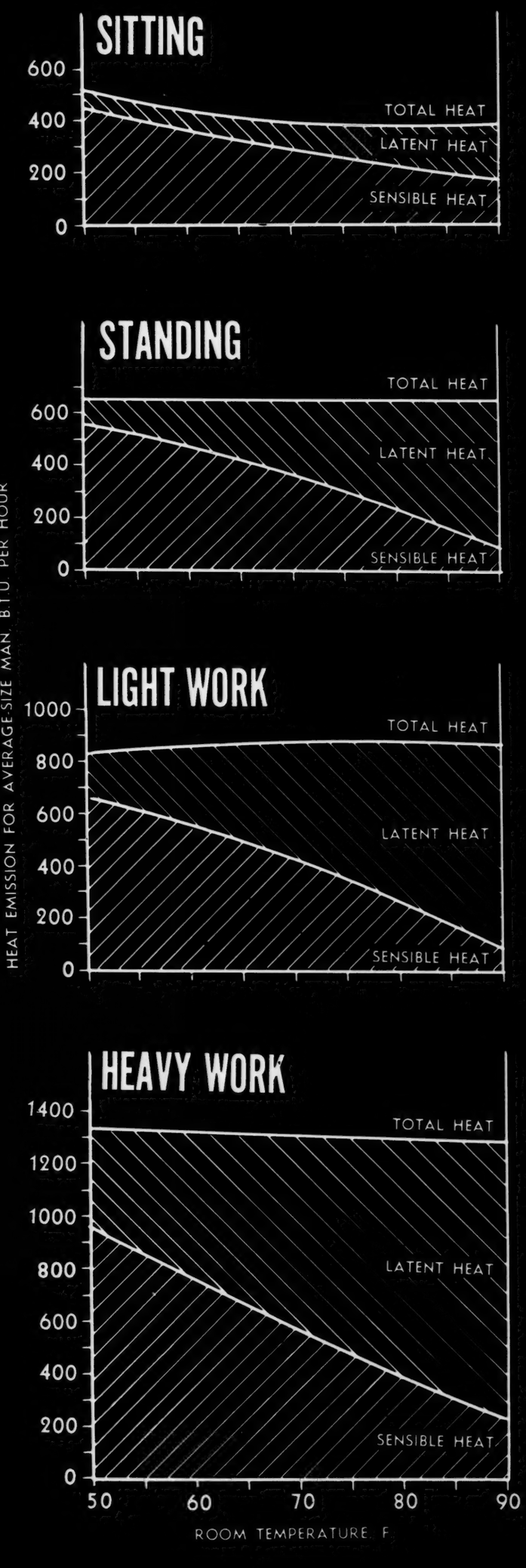


Fig. 2. Latent, sensible and total heat emission of human beings at different room temperatures and at different degrees of activity.

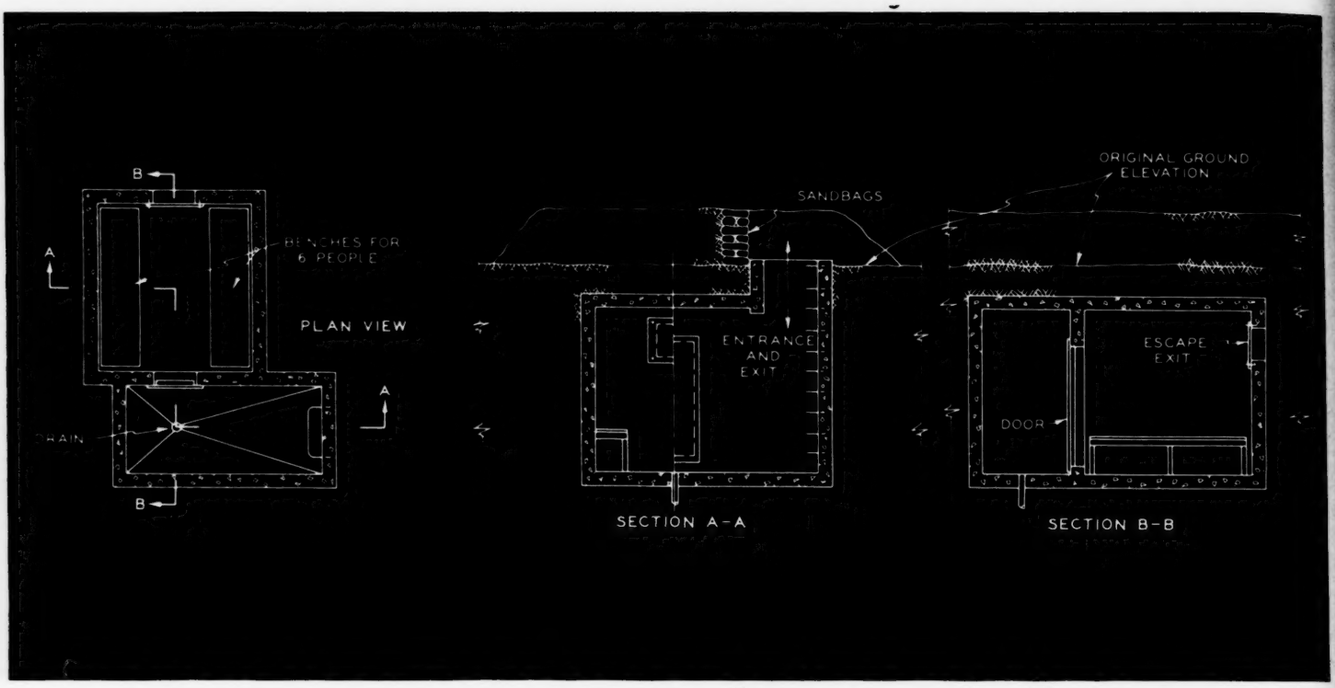


Fig. 3. Plan view and sections of typical, non-ventilated, buried, splinter-proof air raid shelter for six persons.

low water to pass through the surface of the skin, cooling by evaporation. In high humidities, where rapid evaporation is not possible, it is necessary to increase the air circulation considerably to prevent discomfort and eventual physiological damage. The upper limit of effective temperature to which the human organism is capable of adapting itself without serious discomfort or injury is 90F effective temperature for men at rest and between 80 and 90F effective temperature for men at work, depending upon the rate of exertion. The series of graphs presented here, Fig. 2, show the relation of activity and heat emission clearly. The charts are, again, a liberal interpretation of Houghten's data from tests at the ASHVE Research Laboratory a decade ago. During heating season, there should be a movement of air of between 15 and 25 fpm, while during the summer this air velocity may be increased to as high as 60 fpm without undue draft sensation.

(Opposite page) Fig. 6. Typical door jamb with six or more special nuts and grippers. Fig. 7. By-pass and switch for system illustrated in Fig. 5. Fig. 8. Venturi air circulator for shelter in Fig. 3, valuable if power fails. Fig. 9. Bomb resistant shelter for 100 people. See Fig. 12 for ventilating equipment. Fig. 10. Hose method of creating air tight door. Fig. 11. Typical set-up of air conditioning equipment and generator set for use during power failure. Circulating water passes through condenser, compressor, and engine before discharge to drain.

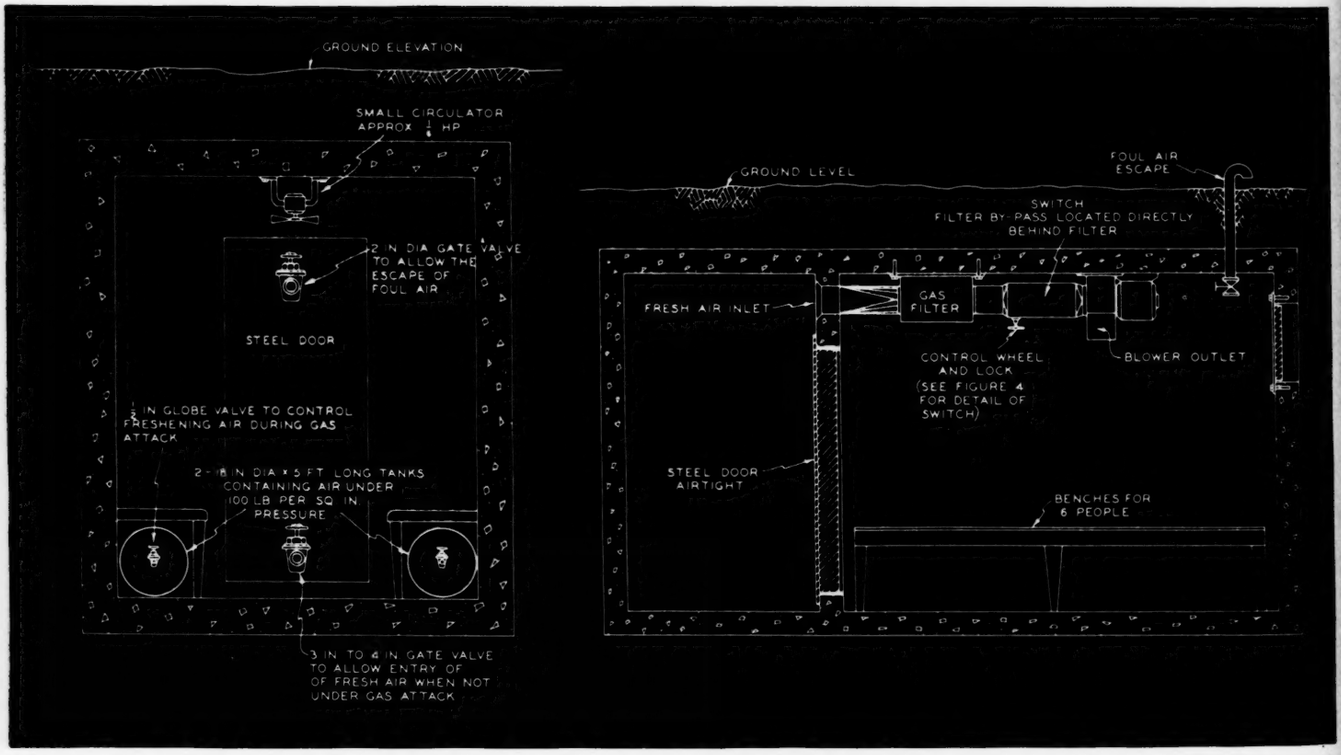
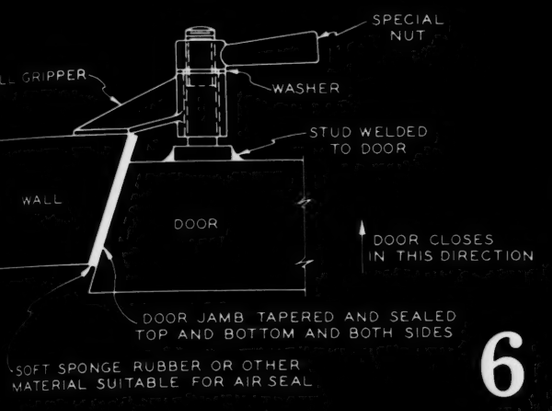
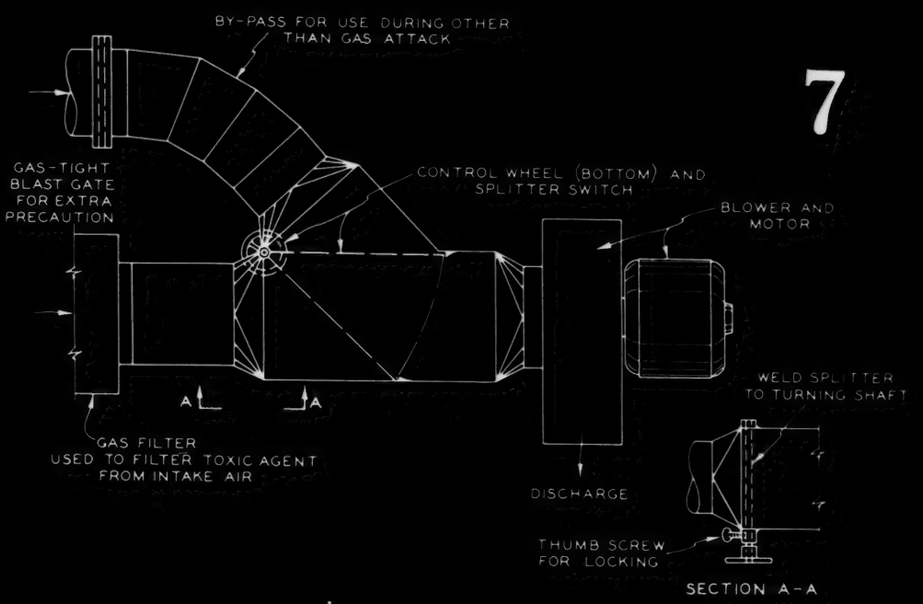

GROUND ELEVATION
SMALL CIRCULATOR APPROX ½ HP
2 IN DIA GATE VALVE TO ALLOW THE ESCAPE OF FOUL AIR
STEEL DOOR
½ IN GLOBE VALVE TO CONTROL FRESHENING AIR DURING GAS ATTACK
2 - 18 IN DIA X 5 FT LONG TANKS CONTAINING AIR UNDER 100 LB PER SQ IN PRESSURE
3 IN TO 6 IN GATE VALVE TO ALLOW ENTRY OF OF FRESH AIR WHEN NOT UNDER GAS ATTACK
GROUND LEVEL
FOUL AIR ESCAPE
SWITCH
FILTER BY-PASS LOCATED DIRECTLY BEHIND FILTER
FRESH AIR INLET
GAS FILTER
CONTROL WHEEL AND LOCK (SEE FIGURE 4 FOR DETAIL OF SWITCH)
BLOWER OUTLET
STEEL DOOR AIRTIGHT
BENCHES FOR 6 PEOPLE

Fig. 4 (Left). The air raid shelter shown in Fig. 3 fitted to withstand gas attack of as long as five to six hours. Fig. 5 (Right). The air raid shelter of Fig. 3 fitted with blower and gas filter for extended gas attacks. The switch detail referred to is Fig. 7, not Fig. 4 as indicated.

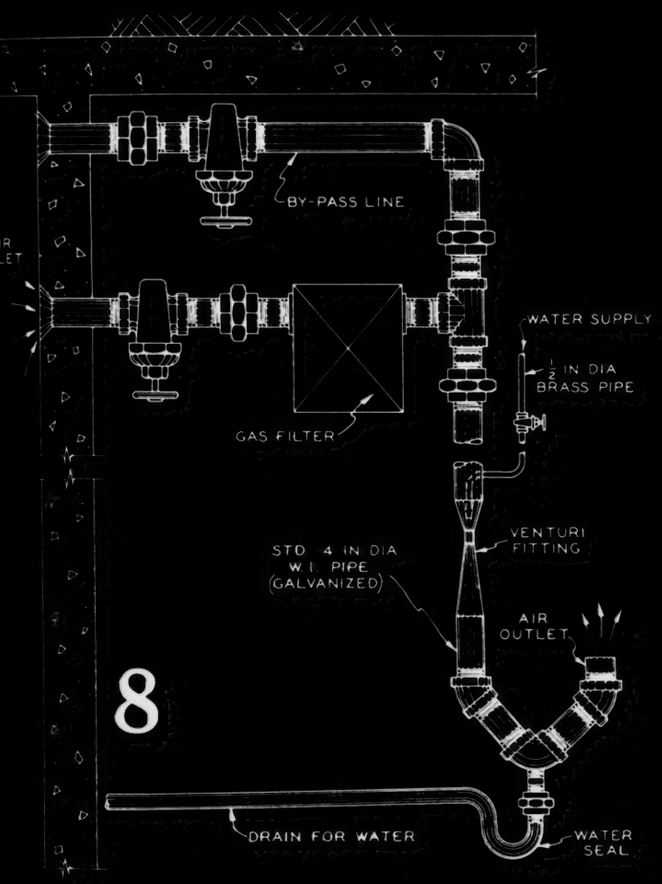
DETAILS OF MECHANICAL EQUIPMENT FOR AIR RAID SHELTERS


SPECIAL NUT
WASHER
STUD WELDED TO DOOR
WALL
DOOR
DOOR CLOSES IN THIS DIRECTION
DOOR JAMB TAPERED AND SEALED TOP AND BOTTOM AND BOTH SIDES
SOFT SPONGE RUBBER OR OTHER MATERIAL SUITABLE FOR AIR SEAL

6


BY-PASS FOR USE DURING OTHER THAN GAS ATTACK
GAS-TIGHT BLAST GATE FOR EXTRA PRECAUTION
CONTROL WHEEL (BOTTOM) AND SPLITTER SWITCH
BLOWER AND MOTOR
WELD SPLITTER TO TURNING SHAFT
A
A
GAS FILTER USED TO FILTER TOXIC AGENT FROM INTAKE AIR
DISCHARGE
THUMB SCREW FOR LOCKING
SECTION A-A

7



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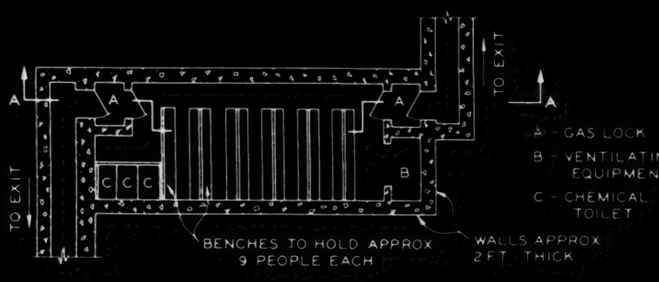
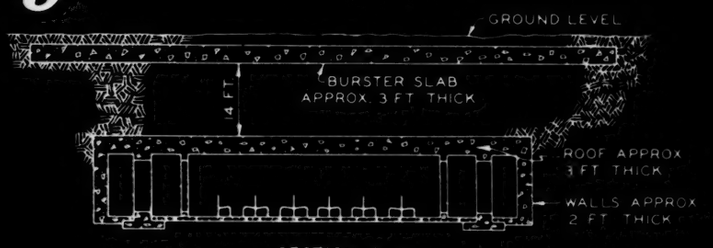
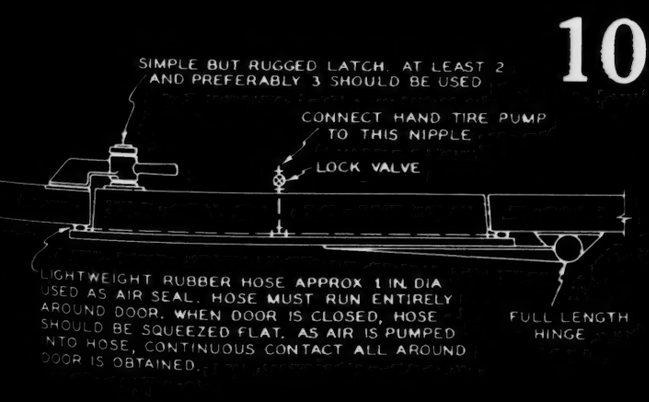


PLAN VIEW

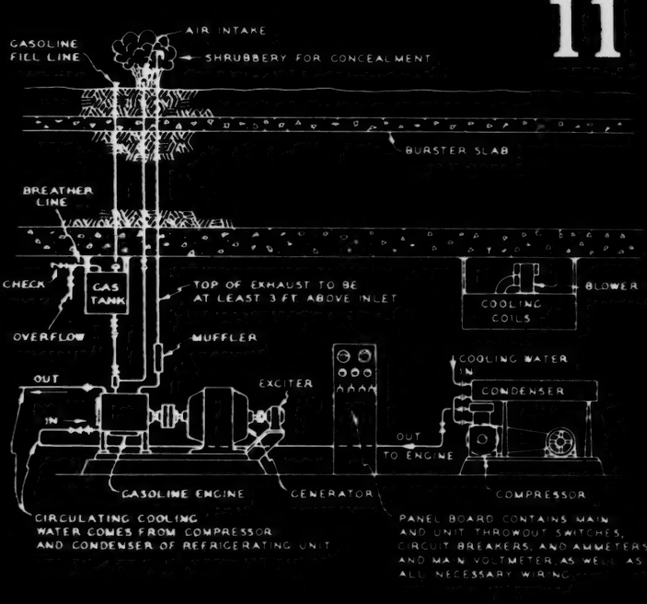
9



SECTION A-A


SIMPLE BUT RUGGED LATCH. AT LEAST 2 AND PREFERABLY 3 SHOULD BE USED
CONNECT HAND TIRE PUMP TO THIS NIPPLE
LOCK VALVE
LIGHTWEIGHT RUBBER HOSE APPROX 1 IN DIA USED AS AIR SEAL. HOSE MUST RUN ENTIRELY AROUND DOOR. WHEN DOOR IS CLOSED, HOSE SHOULD BE SQUEEZED FLAT. AS AIR IS PUMPED INTO HOSE, CONTINUOUS CONTACT ALL AROUND DOOR IS OBTAINED.
FULL LENGTH HINGE

10



11

TYPES OF BOMBS

Let us now investigate, briefly, the various types of bombs and the types of shelters necessary for adequate protection against these bombs. In general, bombs are divided into the following classifications: armor-piercing, demolition, fragmentation, aerial mine, incendiary light and scatter, and gas.

The *armor-piercing bomb*, weighing around 1100 lb, is primarily designed for use against warships and other special targets. It has excellent penetration due to its high terminal velocity and heavy steel case, but its blast is necessarily reduced due to the comparatively low percentage by weight of explosive. While shelters can be provided to withstand such bombs, their cost would be prohibitive except in the case of special military targets such as power, water, and communication stations and sub-stations, vital machinery and control rooms at locks and dams. Since such bombs are rarely used against any targets except such as the foregoing, due to the comparatively low blast effect, it is unnecessary to design for such an eventuality.

The *demolition bomb*, designed for use against buildings, bridges, and military concentrations, weighs about 550 lb and has a higher percentage of explosive than the armor-piercing bomb. As a result, such bombs have a heavy blast effect. In Fig. 6 is illustrated a bomb resistant shelter for 100 persons. Such a shelter will resist the demolition bomb except under an unusually long and accurate series of bomb raids.

The *fragmentation bomb*, very light in weight (only 30 lb), has very poor penetration and a light blast. Designed for use against personnel and transport, it fragments easily throwing a large number of small splinters in all directions.

Aerial mines weigh about 2000 lb, although they are on occasion built much larger. They are provided with parachutes to bring the bomb to rest without case damage or penetration. An instantaneous fuse sets off a terrific blast (such bombs are 90% explosive) and wholesale demolition over a wide area may result if they land in a section of weak structures. These bombs have little effect on the bomb shelter of Fig. 9. However, such a bomb bursting next to the entrance of a splinter-proof shelter would generally demolish it.

While both the shelters illustrated in Figs. 3 and 9 are proof against penetration of either the *incendiary light or scatter bombs*, if either happens to land near the entrance of a splinter-proof shelter, the heat generated will be sufficient to drive the occupants from the shelter. While this can be prevented by water cooled doors, or other insulating precautions of an elaborate nature, this puts such a shelter near the price class of the bomb-proof shelter of Fig. 9.

Gas bombs which usually contain a persistent gas such as mustard gas but which may also contain tear gas, arsenic compounds, chlorine, or Lewisite have very poor penetration and no blast. The persistent gases are usually formed from liquids which boil at a very high temperature and vaporize very slowly. The liquid may collect in out of the way corners and pockets, where it vaporizes slowly, and is a source of great danger long after an attack has been made and the bomb dropped. When such gases find their way into a compartment which is in any way warmed, they constitute a serious menace until the compartment is completely cleared.

Non-persistent gases are gases at ordinary atmospheric conditions and form gas clouds immediately upon the bursting of a bomb (or shell). Chlorine and phosgene boil at very low temperatures and vaporize readily, phosgene, in fact, boiling at 47F. However, such gases will not remain in exposed places for longer than a few minutes.

Toxic smoke is dispersed in extremely fine, solid particles like dust. The particles themselves are very irritating and give off poisonous vapors very slowly. They may be used in bombs containing, in addition, a large amount of high explosives; thus, such bombs are extremely dangerous to mere splinter-proof shelters. The gases commonly referred to as "d.a." (diphenylchlorosine) and "d.m." (diphenylaminochlorosine) belong to the toxic smoke class.

While the effects of toxic gases vary with the nature of the gas, most of them irritate the tissues with which they come into contact, particularly those of the breathing system. The severity of irritation may vary from extreme discomfort of the nose and throat to injury of the lungs serious enough to cause death. Some, like mustard gas, produce serious burns upon the skin, particularly the tender and moist parts under the arms and around the scrotum. Some are extremely irritating to the eyes and may cause temporary blindness.

TYPES OF SHELTERS

It is apparent from the above description that regardless of the type of shelter provided, to be at all effective in the protection offered they must be gas proof. Accordingly, the following fundamentals must be included in the design.

1. All doors and other means of access and egress must be made as gas-tight as possible.
2. The interior of the shelter should be under a slight positive pressure, especially during a gas attack. A few inches water gauge will suffice.
3. All fresh air inlets must be fitted with valves and all gas filters with by-passes (see Fig. 12).
4. A gas alarm notifying those within the shelter of a gas attack is essential for many gases do not make their action felt immediately and are accordingly more dangerous. This is a community and individual problem.
5. Some means of introducing fresh air or of conditioning and distributing the existing air within the shelter must be provided.

There are many ways of making doors air-tight, some more elaborate than others. Illustrated in Figs. 6 and 10 are a couple of ways of accomplishing this objective with a minimum expenditure. Fig. 6 illustrates the tapered door jamb with soft seal and six or more vise-type grippers to make door air-tight after it has been closed. Fig. 10 has the step-type door jamb with rubber hose seal. As the door is closed the hose assumes a flattened shape. After the latches are set, air is pumped into the hose, thus effectively sealing the door cracks. Both these methods may be used in duplicate (or in combination) to form an air lock so that passage may be effected between the shelter and outside or vice-versa without admitting more than a trace of outside air. Actually, a scavenger may be used to expunge all such air (plus contaminant) before the inner door is opened. Fig. 9 illustrates a bomb proof shelter with gas locks incorporated.

While it is urgent that every effort be made to secure a gas-tight door, it is nevertheless a fact that such doors are prone to lose their effectiveness with time. Hence, it is best to maintain a positive pressure differential within the shelter of about 3 to 4 inches of water gauge over atmospheric pressure. Thus, in the event of a leak, air-flow will be outward rather than inward. Such a positive pressure differential may be obtained in various ways. Thus, for the large bomb shelter of Fig. 9, a centrifugal blower may be used connected as shown in Fig. 7 and Fig. 12 and of sufficient capacity and head to introduce enough air to offset the leakage existing and still maintain the internal pressure desired. This may be substituted by an axial blower (disc fan designed to work against a head of some 3 to 4 inches of water

gauge). During a gas attack such air as is introduced must be run through the gas filter which interposes additional resistance to flow.

The small splinter-proof shelter of Fig. 3 can use the same scheme as illustrated in Fig. 5 or the idea illustrated in Fig. 4, which is not dependent on a gas filter. This latter scheme utilizes two or more air tanks under a gauge pressure of as high as 75 to 100 lb per sq in. and a small circulating fan in the ceiling. As the air within the chamber becomes stale, fresh air is released from one or both of the tanks. As the pressure within the room becomes uncomfortably high, one of the valves (preferably the upper one, Fig. 4) is opened momentarily relieving this condition. Such a set-up, however, is effective only as long as there is air under any appreciable pressure left in the tank. As it becomes exhausted the air becomes unbearably foul. A unit such as illustrated can be used to good effect over a period of as high as 5 to 6 hours continuously. Beyond that point, the tanks must be refilled at a nearby gasoline station, for example.

The venturi air circulator illustrated in Fig. 8 is still another means of introducing fresh air and maintaining the desired pressure differential. As can be seen from the illustration, water under normal city pressure is introduced, through a ½ in. brass pipe, into the throat of the venturi tube causing a negative pressure immediately behind this point. This negative pressure, in turn, induces air to flow into the chamber. While the volume of air induced is dependent on the water pressure available, the relative sizes of the water and air pipes, the resistance to flow in the air tube ahead of and behind the throat and the efficiency of impact (between water and air), the set-up illustrated is amply effective for the small shelter in question.

All fresh air pipes should be valved so that, in the event of a gas attack, complete isolation from the deadly fumes may be obtained. Where gas filters are used, by-passes should be provided so that repairs and replacements may be effected without danger to the occupants within the shelter.

The question of alarms is an important one and, happily, one which is being well-provided for in plans for civil defense. Not only is it necessary that the populace be advised of an air raid, but it is essential that proper warning may be given in the event of a gas attack. Sirens which can be heard in shelters by special amplifying sets and electrically connected buzzers set off at a central warning station are two methods of providing warning. This can be supplemented by gas raid wardens making the rounds.

One of the really important problems to be met in the design of adequate air-raid shelter ventilation is the problem of carrying on during power failure. Not only must the problem of lighting the shelter be met but the more serious one of circulating existing air and introducing fresh air must be overcome.

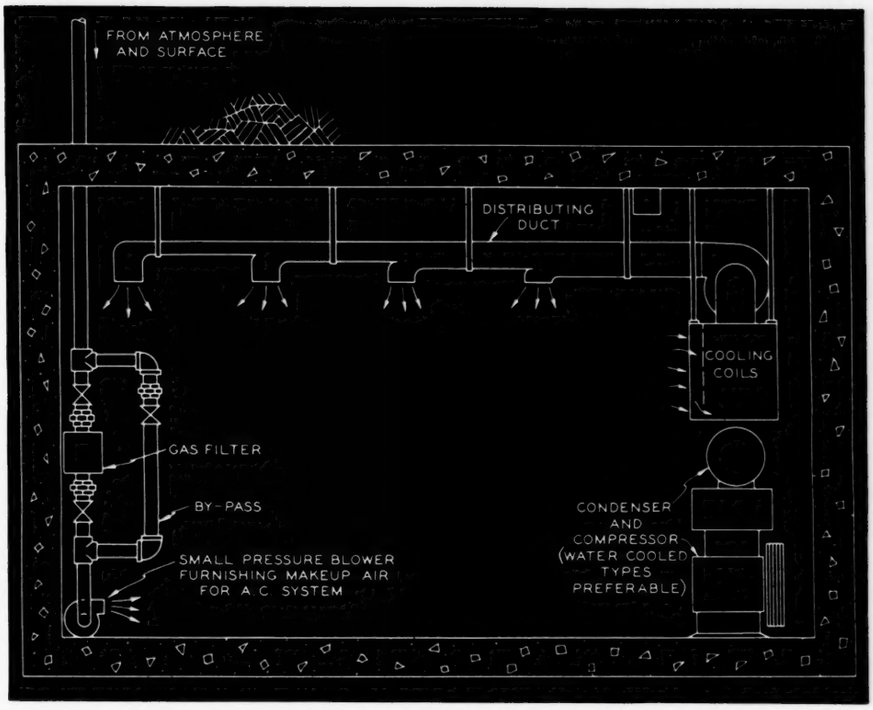


Fig. 12. Typical air conditioning and ventilating lay-out for bomb shelter similar to that in Fig. 9.

While the most practical method of handling this problem for small shelters where there is a definite limit to the money which may be spent on accessories seems to be the venturi circulator (water operated) plus a storage battery sufficiently large to handle an emergency lamp or two; or to use a direct current fan which can be run from the storage battery itself charged by a small water wheel, or d.c. generator driven by an a.c. motor which, of course, is down during power failure, other methods, all of which have some merit, may be used. For instance, a fan driven by a water wheel together with a battery to handle lights; or a d.c. motor, deriving its current from a battery, driving an alternator which provides current for motor and lights. Here, however, considerable charging would be necessary in order to keep the battery at a high service level for periods of power failure.

In case of large shelters serving from fifty to five hundred or more persons, more elaborate equipment may be used with justification. Such shelters may economically provide air conditioning since by doing so, the amount of fresh air necessary for introduction will be materially reduced, reducing the sizes of gas filters, blowers, motors, and ducts. Illustrated in Fig. 11 is a typical set-up for auxiliary drive of air conditioning equipment during power failure. Illustrated is a gasoline-driven alternator and exciter which will provide the current necessary for the blower, compressor and water pump motors (if washing equipment is used and re-circulation employed) as well as the necessary current for lights. Breather pipes for gasoline tanks may be allowed to draw its air from the shelter atmosphere, but a sensitive check valve should be placed in this line to prevent fumes from escaping into the shelter proper. The inlet or filler pipe for the gasoline tank must, of necessity, be run to the existing grade level or thereabouts in order to facilitate regular refilling. However, as illustrated, mechanical disconnection should be effected so that a direct hit from even a large splinter will not ignite the tank contents. Inlet and exhaust pipes for the gasoline engine may be carried to the ground level without any undue danger. Air contaminated by gas will still support combustion so it is unnecessary to filter this air.

All of the methods described have their advantages and disadvantages. Some, depending on water as the prime moving medium, are subject to water pressure failure, others depending on batteries to low-charge conditions. Some methods are expensive and some inconvenient. However, all of the methods will offer protection over a reasonable length of time. With reasonable amount of maintenance they may suffice for as long as is necessary. The individual conditions surrounding each problem and the availability of parts and materials will help determine which method of ventilation should be used. However, it would be wise to have each shelter provided with such emergency items as gas masks, flash lights, picks and shovels.

VENTILATION vs. GAS

By JOSEPH F. KERN, JR.†

In designing air raid shelters the engineer is interested in controlling not only the temperature and humidity of the air but also the oxygen, carbon dioxide and poison gas content. At the same time, he is interested in knowing the conditions which must be maintained for comfort and the conditions which the occupants can withstand in times of emergency without serious danger to their health.

Types of Shelters

From the standpoint of ventilation air raid shelters may be classified into four general groups: (1) shelters which are completely gas tight, have no ventilation equipment, and with air for breathing taken from the air within the room; (2) shelters which are completely gas tight, have no ventilation equipment, and with air for breathing obtained from apparatus for revitalizing the air; (3) shelters with natural ventilation in which protection from gas is secured by use of gas masks, and (4) shelters with mechanical ventilation equipment, with protection from gas secured by filters in the ventilating equipment.

The first type of shelter is the simplest from the standpoint of ventilation. However, considerable care must be taken to make the room entirely gas-proof so that there can be no infiltration of poison gas from the outside. This is extremely important since air pressure in the shelters is the same as the outside, which makes these types of shelters particularly liable to infiltration.

TABLE 1. EFFECT OF REDUCED CONCENTRATIONS OF OXYGEN ON HUMANS

Oxygen Concentration, Percent	Remarks
21	Normal air conditions
17	Candle is extinguished
14	Slight effect on humans
12	Breathing becomes difficult
10	Body and mental activity becomes difficult
6	Consciousness is lost
3 to 4	Death takes place

In order to estimate the time that these shelters can be occupied it is necessary to take into account the amount of oxygen used by the occupants, the amount of carbon dioxide produced, and also the heat and moisture production of each occupant. The average adult when at rest or slightly active will consume roughly 0.8 cu ft per hr of oxygen and will produce approximately the same amount of carbon dioxide. Thus in a completely closed room the oxygen content will continually decrease from the normal 21% while the carbon dioxide will continually increase from the normal 0.04%. When the occupants are very active, such as in a shelter where they are operating a pedal or hand driven blower, the rate of oxygen consumption will increase greatly as will the carbon dioxide production. Under these conditions an average adult may be considered to consume, roughly, 1.2 cu ft per hr of oxygen and will produce about the same percentage of carbon dioxide.

UNVENTILATED SHELTERS

From the standpoint of respiration the principal factor which determines the length of time that the unventilated shelter can be occupied is the increase of carbon dioxide content of the room. Normal adults in good health will not be affected by carbon dioxide contents up to 2% or 3% except in that their breathing rate will increase slightly. However, by the time that the carbon dioxide content increases to 5% or 6% the breathing rate will be doubled and some occupants will develop nausea and headache. A 10% carbon dioxide content is extremely dangerous and can not be endured for more than a few minutes.

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TABLE 2. MAXIMUM TIME AN UNVENTILATED, GAS TIGHT SHELTER CAN BE OCCUPIED

Shelter Volume, Cu. Ft. Per Person	Limiting Carbon Dioxide Content of Air											
	2%—Suggested By OCD				5%—Headache and Nausea				10%—Fatal			
	Activity of Occupants											
	Adults			Children At Rest	Adults			Children At Rest	Adults			Children At Rest
	At Rest	Light Work	Heavy Work		At Rest	Light Work	Heavy Work		At Rest	Light Work	Heavy Work	
	Maximum Time Shelter Can Be Occupied, Hours											
10	¼	¼	..	½	½	½	¼	1	1	1	¾	2.5
20	½	½	¼	1	1	1	¾	2½	2½	2½	1½	5
30	¾	¾	½	1½	2	1½	1	3	4	3	2½	7
40	1	1	½	2	2½	2½	1½	5	5	5	3	10
50	1	1	¾	2½	3	3	2	6	7	6	4	12
60	1½	1½	1	3	4	3	2½	7	8	7	5	15
75	2	1½	1	3	5	4	3	9	10	9	6	18
100	3	2	1½	5	7	6	4	12	14	12	8	25
120	3	3	2	6	8	7	5	15	17	15	10	30
140	4	3	2	7	10	8	5	17	20	17	11	35
160	4	4	2	8	11	10	6	20	23	20	13	40
180	5	4	3	9	12	11	7	22	25	22	15	45
200	5	5	3	10	14	12	8	25	29	25	16	50
250	7	6	4	12	17	15	10	31	36	31	21	62
300	8	7	5	15	21	18	12	37	43	37	25	75
350	10	8	5	17	25	22	14	44	50	44	29	87

Table 2 has been calculated to show the time that a shelter can be occupied before the carbon dioxide content reaches a given amount. Actually in shelters constructed of concrete it will be possible to occupy the shelter for a longer period before the concentration shown is reached because some of the carbon dioxide is absorbed by the concrete. For this reason it is desirable not to line concrete shelters with steel or waterproofing since these substances will interfere with the absorption of the carbon dioxide.

The oxygen supply in the room is adequate even when the shelter has been occupied long enough so that a 10% carbon dioxide content is produced. With 10% carbon dioxide content the oxygen content is still about 11% which would correspond to the amount of oxygen in air about 16,000 ft altitude. Under these conditions breathing is difficult but not impossible. However, as explained previously it is the carbon dioxide content which limits the length of occupancy.

Carbon Dioxide Limit

The Office of Civilian Defense recommends that the carbon dioxide con-

tent should not be allowed to increase over 2%. This figure is probably based on the fact that while this percentage is not dangerous to a normal healthy adult it may be dangerous to older people and children. British authorities recommend that the percentage be kept to 3% or below.

Tests in unventilated air raid shelters in which the carbon dioxide content was allowed to increase to slightly over 5% resulted in some of the subjects developing headaches and nausea. In these tests the shelter was occupied for a period of roughly two hours in order to produce the 5% carbon dioxide.

Therefore, in unventilated gas tight shelters which are being designed to maintain comfortable conditions, sufficient volume should be provided so that the carbon dioxide content will not increase beyond 2% or 3% during the maximum time of occupancy. However, in case of emergency it would be possible for the people to occupy the shelter even though the carbon dioxide content was slightly over 5% without any serious health hazards.

Effect of Temperature and Humidity

Even more important from the standpoint of limiting the length of occupancy of unventilated underground shelters is the temperature and humidity.

In an unventilated underground shelter the heat released by the occupants serves to warm both the air in the shelter and the walls of the shelter. Since underground shelters are built with concrete or steel walls and since the walls are backed by relatively cool earth, the walls can absorb a considerable amount of heat without any great rise in temperature.

As unventilated shelters would not be used continuously, when they are first occupied the air temperature will be close to the ground temperature. The air temperature will rise rapidly after occupancy until there is a great enough temperature differential between the air and wall surface to cause an appreciable flow of heat. This is shown in Fig. 1 which shows the air temperature rise in typical underground concrete and steel shelters.

Practically all tests indicate that during the first half hour or so the air temperature rises quite rapidly and then it gradually tapers off and the rise, after an occupancy of an hour, is relatively small. An idea of how much a temperature rise can be expected in underground shelters can be obtained from Table 4. This table shows the temperature rise during the first hour of occupancy in both ventilated and unventilated shelters.

It is a difficult problem to estimate the amount of wall surface which should be provided to carry off the body heat from the occupants so as to prevent the shelter from becoming unbearably hot during the expected period of occupancy. Both the U. S. Office of Civilian Defense and the British Air Raid Precautions Department have made recommendations as to the amount of surface which should be provided. The Office of Civilian Defense recommendations are that 20 sq ft of floor space should be allowed for each person occupying the enclosure. They state that with a normal height room this should give ample wall surface area for dissipation of the body heat. With this allowance the air temperature rise will be about 16 to 17F during an 8 hr occupancy. The British recommendation is that a wall surface of 75 sq ft should be provided per person for a three-hour occupancy and 100 sq ft per person for a 12-hour occupancy.

TABLE 3. EFFECT OF CARBON DIOXIDE ON HUMANS

Concentration CO_2, Percent	Remarks
0.04	Normal air conditions
2.	Limit suggested by Office of Civilian Defense
3.	Limit suggested by British Air Raid Precautions Department
5.	Breathing rate doubled, headache, nausea
10.	Cannot be endured for more than a few minutes

When these allowances are compared with the test results previously mentioned, it can be seen that they are quite liberal. However, it is well to allow more surface than is absolutely necessary since conditions may require that more people (than calculated) occupy the shelter or that it may be necessary to occupy it for longer periods than it was designed for.

The relative humidity of the air will probably not be the limiting factor since the wall temperature of the shelter will be lower than the air temperature and, therefore, as the relative humidity tends to build up, some of the moisture will be condensed on the walls. That this is true can be shown by the following examples.

If, under summer conditions, the air temperature in the shelter reaches 95F during the period of occupancy, it is doubtful if the wall temperature would exceed 80F during short periods of occupancy since the ground temperature, in practically all sections of the United States, would be 70F or less during the summer. Therefore, with an 80F wall temperature and 95F air temperature a maximum relative humidity for the air in contact with the walls would be about 65%. If the air was circulated in the shelter

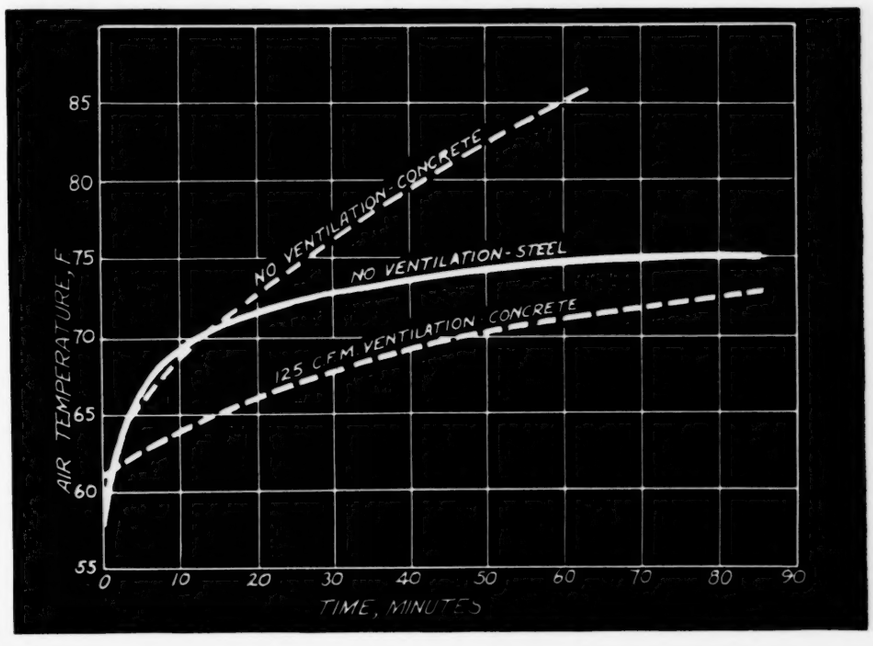


Fig. 1. Temperature rise in unventilated and ventilated underground shelters. It can be seen that the air temperature increase is rapid during the first few minutes of occupancy, then it increases rather slowly. It has been noted that in practically all shelters that the temperature rise is very small after the first hours of occupancy. Note the difference in temperature rise in the unventilated and ventilated concrete shelters.

INFORMATION ON GASES LIKELY TO BE USED IN WARFARE

Type of Gas	Name of Gas	Chemical Formula	Form	Odor	Persistence	Melting Point, F	Boiling Point, F	Density	Dangerous Concentration, 10 Min Exposure, Oz per 1000 Cu Ft		Remarks
									Irritant	Lethal	
Vesicants (skin blisterers)	Mustard (Dichlorethyl-sulfide)	$(ClCH_2CH_2)_2S$	Liquid and Vapor	Garlic, Mustard, Horseradish	1 day to 1 week; longer, if cold	58	423	Heavier than air	0.001	0.15	Most effective gas used in last war
	Lewisite (Chlorvinyl-dichlorarsine)	$CHClCHAsCl_2$	Liquid and Vapor	Geraniums	1 day to 1 week; longer if dry and cold	9	374	—	0.0008	0.12	Powerful. Expect this in cold weather rather than mustard gas. Not suitable in moist air
Lung Irritants	Ethyldichlorarsine	$C_2H_5AsCl_2$	Liquid and Vapor or Gas	Stinging, like pepper in nose	1 hour	—	313	—	0.001	0.50	Severe on long exposure
	Chlorine	Cl_2	Gas	Pungent	10 minutes	—	—28	Much heavier than air	0.029	5.60	First gas used in last war
	Chlorpicrin (Nitrochloroform)	CCl_3NO_2	Gas	Flypaper, Anise	Open, 6 hours Woods, 12 hours	—83	234	Heavier than air	0.009	2.00	Less toxic than phosgene
	Diphosgene (Trichlormethyl-chloroformate)	$ClCOOCCl_3$	Gas	Ensilage, acrid	30 minutes	—70	262	Heavier than air	0.005	0.50	
	Phosgene (Carbonyl chloride)	$COCl_2$	Gas	Musty hay, green corn	10 to 30 minutes	—180	47	About same as air	0.005	0.50	Most toxic of lung irritants
Lacrimators (Tear gases)	Cloracetophenone	$C_6H_5COCH_2Cl$	Gas	Apple blossoms	10 minutes	129	473	Lighter than air	0.0003	0.85	Used as preliminary attack to encourage removal of gas masks because of discomfort, followed by attack with toxic gas
	Brombenzylcyanide	$C_6H_5CHBrCN$	Gas	Sour fruit	Several days, weeks in winter	77	468	—	0.00015	3.5	
	Xylyl bromide	$CH_3C_6H_4CH_2Br$	Gas	—	—	70	424	Lighter than air	—	—	
	Ethyliodoacetate	$CH_2ICOOC_2H_5$	Gas	—	Fair rate of persistence	—	356	—	—	—	
Sternutators (Nose and throat irritants)	Adamsite (Diphenylamine-chlorarsine)	$(C_2H_4)_2NHAsCl$	Gas	Coal smoke	10 minutes	383	770	—	0.00038	3.00	These cause vomiting
	Diphenylchlorarsine	$(C_6H_5)_2AsCl$	Smoke	Shoe Polish	Summer, 10 minutes	109	631	Lighter than air	0.0005	1.50	
	Diphenylcyanoarsine	$(C_6H_5)_2AsCN$	Gas	—	—	91	655	—	0.0001	1.0	130 mg per cu meter fatal in one-half hour
Smokes	HC Mixture	ZnC_2Cl_6	Smoke	Sharp, acrid	While burning	—	—	—	—	—	Harmless
	Sulphur Trioxide (in chlorsulfonic acid)	SO_3SO_3HCl	Smoke	Causes flow of tears	5 to 10 minutes	—	—	—	—	—	Not toxic
	Titaniumtetra-chloride	$TiCl_4$	Smoke	Acrid	10 minutes	—22	277	—	—	—	Smoke gives off on contact with damp air. Not toxic
Systemic (Internal poisoning)	Hydrocyanic acid	HCN	Gas	Bitter Almonds	Very low	7	79	Lighter than air	0.020	0.2	Disperses rapidly in air and consequently difficult to use. Extremely toxic
	Carbon monoxide	CO	Gas	Odorless	Very low	—341	—310	Slightly lighter than air	—	—	Combines too rapidly with O_2 for use in open
	Hydrogen sulphide	H_2S	Gas	Rotten eggs	Very low	—117	—80	Heavier than air	—	—	Tried in last war but use abandoned

the relative humidity in the center of the shelter would probably not exceed 70%.

That this wall condensation actually takes place was shown in tests made on an air raid shelter in England. After a two-hour period of occupancy with 47 people in an unventilated shelter the calculated amount of humidity in the air was 42 gr per cu ft, assuming no condensation. The actual humidity was found to be 6.7 gr per cu ft indicating that approximately 35 gr per cu ft was condensed on the wall and floor surfaces.

Odors in Unventilated Shelters

Gas-tight shelters which are not ventilated build up a very noticeable odor concentration within a short period after they are occupied. An idea of how rapidly the odor builds up can be obtained from the results of tests made in a school room, ventilated at the rate of 7.5 cfm per person. The volume of the room was such that there was 200 cu ft of spare per person but even under these conditions the odor level reaches a disagreeable point within 30 minutes. If this occurs in a lightly occupied room and with ventilation rate of about 500 cu ft of air per hour per person, some idea can be had of the odor level in a sealed shelter with no ventilation in which only 120 cu ft of space is allowed per person.

In all probability the odor level will not be noticeable as such by occupants of the room since the nose rapidly loses its ability to distinguish odors. The principal objection on the part of the occupants will be, even if the temperature and humidity are maintained correctly, complaints of stuffiness and closeness of the air. This probably will result in headaches and nausea after exposure of two or three hours.

If it is felt desirable to limit the odors, activated carbon odor adsorbers are available. In small rooms a portable odor adsorber equipped with a fan would help reduce the odor level in the room and at the same time provide some circulation of air. Larger rooms could be equipped with two or more of these units or with larger odor adsorbers used for design in duct work.

One type of odor adsorber on the market utilizes activated granular coconut shell carbon which is said to hold more than 20% of its own weight of odors. Under normal conditions this filter is said to keep its high efficiency during several years of operation and it may be reactivated.

TABLE 4. AIR TEMPERATURE RISE IN UNDERGROUND SHELTERS

Shelter	Inside Surface Sq. Ft. Per Person	Temperature Rise, F. in 1st Hour
Steel—	19	18
Unventilated	21	16.5
Concrete—	17	24
Unventilated	14	25
Concrete—		
Ventilated	14	12

REVITALIZED AIR SYSTEM

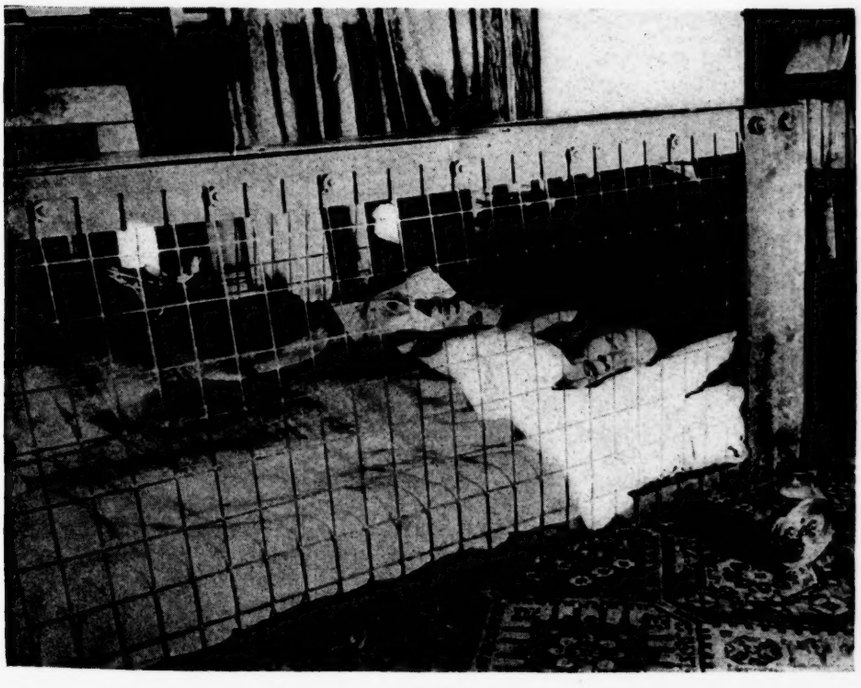
The second type of shelter is quite like the first except that it is equipped with apparatus for revitalizing the air. Since these types of shelters are, in general, designed to be occupied for longer periods than the first type, considerable more surface area must be allowed to carry off the body heat. The equipment installed is designed to absorb the carbon dioxide from the air and to supply oxygen.

One of the simplest methods of doing this is to employ a chemical which, when dissolved in water, releases oxygen and at the same time forms a caustic solution which will absorb the carbon dioxide of the air. This method of revitalizing the air has the advantage in that it does not require any expensive equipment but the operating costs are relatively high since the chemicals are expensive and in some cases quite difficult to obtain.

Caustic soda or soda lime is usually employed for absorbing carbon dioxide from the air. These materials can be used in the dry form or in the liquid form. In some British shelters the soda lime is hung in bags from the ceiling so that as much surface as possible is exposed to the air. This method is not too satisfactory but will work and requires a minimum of equipment.

A more efficient method is to use the water solution of the caustic soda and pass the room air through a spray of this solution. At the present time such equipment is used for controlling the carbon dioxide content in fruit storage rooms. In this equipment a diluted solution of flake caustic soda (sodium hydroxide) is circulated by a small centrifugal pump to the top from which the solution flows down through a series of perforated baffle plates to a reservoir. The room air is drawn into the unit, passes up through the perforated plates and is then discharged back into the room. See Fig. 4.

One of these units capable of treat-



Photos, Press Association, Inc.

Fig. 2. Morrison type shelter which was developed in England to provide protection for people in dwellings. This shelter is essentially a reinforced box with open sides covered with wire mesh and is designed primarily to protect the occupants from falling plaster and beams.

TABLE 5. MINIMUM VENTILATION AND SPACE REQUIREMENTS FOR AIR RAID SHELTERS

Location of Shelter	Maximum Time of Occupancy, Hours	Ventilation Rate Cu. Ft. Per Hr. Per Person	Total Surface Needed, Sq. Ft. Per Person	Floor Area, Sq. Ft. Per Person	Volume, Cu. Ft. Per Person
Above Ground	3	Gas Tight	75	6	120
	3	Natural	50	6	50
	3	150	40	6	50
	3	450	30	4.5	35
	12	Gas Tight	100	6	350
	12	Natural	60	6	75
	12	450	60	8	50
	Over 12	600	50	10	70
Below Ground	3	Gas Tight	75	6	120
	3	Natural	30	6	50
	3	150	20	6	50
	12	Gas Tight	100	6	350
	12	Natural	40	6	75
	12	450	25	6	30
	Over 12	600	30	8	60

ing 150 cfm of air was equipped with a pump having a capacity of 6 gpm of caustic soda solution made up of 1/3 lb flake caustic soda per gal. The tower was made of 12 baffle plates 24 in. in diameter, spaced 3 in. apart and perforated with 5 in. holes. Holes were spaced 2 in. apart on each plate. The air was drawn in through a 4 in. opening just above the reservoir and was passed through the perforated plates to a fan which forced it back into the room. This tower was constructed of 14 gauge black iron, arc-welded. It was found that the alkaline solution had but a slight effect on this iron.

After some time the caustic soda solution will become weakened and it is then necessary to replace it with fresh solution. Stronger concentrations will result in more complete removal of the carbon dioxide but may cause the unit to clog up due to crystallization of this caustic soda.

Oxygen Concentrations

The use of some method of absorbing the carbon dioxide will enable a gas tight room to be occupied for a longer period since the carbon dioxide content is controlled. However, when no means of introducing additional oxygen is provided the time of occupancy is limited by the decreasing oxygen content. About 12% oxygen is about the low limit for all practical purposes. Table 6 shows the length of time shelters can be occupied when the carbon dioxide content is controlled. Where the shelters are to be occupied for considerable periods a tank or tanks of compressed oxygen should be used. When this is done, occupants at rest will require about 0.8 cu ft per hr each. Occupants performing heavy manual work will require 1.2 cu ft per hr each.

NATURAL VENTILATION

The third type of shelter depends upon natural ventilation and protection from poisonous gases as secured by means of gas masks. These shelters are relatively inexpensive and include reinforced rooms above or below the ground in existing buildings. When these rooms are in the basement of a building the British Air Raid Precautions Department states that if the shelter is so placed that it is not adjacent to occupied heated rooms or to rooms housing boilers, it can be regarded as positively ventilated at the rate of 150 cu ft of air per person per hr. These shelters have the disadvantage that they do not offer protection against such poisonous substances as mustard gas or Lewisite which act primarily against the skin. It also means that all persons to be housed in the shelter must be equipped with gas masks.

MECHANICAL VENTILATION

In the fourth type of shelter, one that is mechanically ventilated, the ventilation equipment serves three purposes: (1) it supplies the necessary oxygen for breathing; (2) it removes the expired carbon dioxide, and (3) it removes a part of the heat given off by the occupants.

This type of plant usually consists of a fan, an electrically-driven motor with an auxiliary drive, an air filter, gas filter and a number of accessories, including ducts and intake and exhaust valves.

These shelters when properly designed offer complete protection against all known poison gases, fumes and smokes and do not have to be constructed as well as an unventilated gas-tight shelter since it is possible to build up a static pressure within the shelter to keep the poison gases from filtering in. Due to the fact that part of the heat given off by the occupants is carried out by the exhaust air these shelters can be about a quarter of the size of the gas-tight shelter and, consequently, will require much less material and will be cheaper to construct. A further advantage in having such a small shelter is that due to the difference in size there is less danger in a direct bomb hit.

Air Supplied

In ventilated shelters in order to limit the amount of carbon dioxide to 2% at least 33 cu ft should be supplied per person per hour. For shelters to be occupied three hours or less at least 150 cu ft per hour per person should be supplied. Shelters occupied up to 12 hours should have 450 cu ft per hour per person while shelters occupied over 12 hours should have at least 600 cu ft per hour per person. See Table 5 for more detailed information on air and space requirements.

Blowers

The blowers should be selected so that they are capable of delivering about 10% more than the required volume of air against the static resistance of the ventilating equipment which includes the gas filters. Since the gas filters resistance is apt to be high, in the order of 3 to 5 in. of water, it is a common practice to by-pass the gas filter at all times except during periods of gas attacks. This drops the resistance of the system to 1 in. of water or less, thus reducing the amount of power required or increasing the amount of ventilation air supplied to the shelter. However, it may be that it is a mistake to install this by-pass since there is a danger that during a gas attack the by-pass may not be closed and thus the entire purpose of the ventilating equipment will be defeated.

The blower should be of the type which will not overload itself in case the resistance of the system is decreased due to either by-passing the filter or a break in the ductwork. For these reasons the usual practice is to use a centrifugal type blower which is equipped with backward curved blades.

Blower Motor

Occasionally the blowers are equipped with a two-speed motor so that the fan can be operated at low speed during the period when the filter is bypassed and at high speed when the gas filters are used. The motor should be sized so that it is large enough to operate the blower for long periods without any danger of overheating without attention. Since it is quite possible that the electric current may be shut off during an air raid auxiliary means of driving the blower should be provided.

For small units a manual drive, either hand or foot operated, may be used. The Office of Civilian Defense points out that it would be well to standardize on the size of the gas filters so that the static pressure and size would be such that the power requirements of the fan would be about one-tenth of a horsepower. If this were done it would be possible in an emergency to operate the blower by hand by two people or by foot by one person. They estimated that with such a unit having a resistance of about 4 in. of water it would be possible to draw about 80 cfm through the unit with an expenditure of one-tenth of a horsepower. This would meet the needs of 52 persons supplying about 1½ cfm to each person. They state that normally these units could be driven by ¼ hp motors. For shelters up to about 105 people two units could be used while for shelters up to 150 people three units could be employed.

For shelters housing more than 150 people the Office of Civilian Defense recommends an independent power plant consisting of an electrical generator driven by either a gasoline or propane motor. It is, of course, important in this connection that the internal combustion engine be self-starting or at least simple in starting. It is also important that the unit not be located in the air raid shelter, itself, but in another protected shelter separate from the air raid shelter. If the unit is used to drive an electric generator rather than the fan directly it would be possible to supply enough electricity for lighting the shelter and thus get a double use out of the generator.

TABLE 6. MAXIMUM TIME AN UNVENTILATED, GAS TIGHT SHELTER CAN BE OCCUPIED*

Shelter Volume, Cu. Ft. Per Person	Limiting Oxygen Content of Air											
	17%—Candle Extinguished				12%—Breathing Difficult				6%—Consciousness Lost			
	Activity of Occupants											
	Adults			Children At Rest	Adults			Children At Rest	Adults			Children At Rest
	At Rest	Light Work	Heavy Work		At Rest	Light Work	Heavy Work		At Rest	Light Work	Heavy Work	
	Maximum Time Shelter Can Be Occupied, Hours											
10	½	½	¼	1	1	1	¾	2	2	1½	1	3
20	1	1	½	2	2½	2	1½	4	4	3½	2½	7
30	1½	1	1	3	3½	3	2	6	6	5	3	11
40	2	1	1	4	5	4	3	8	8	7	5	15
50	2½	2	1½	5	6	5	3	11	10	9	6	18
60	3	2	1½	6	7	6	6	13	12	11	7	22
75	4	3	2	7	9	8	5	16	15	14	9	28
100	5	5	3	10	12	11	7	22	21	18	12	37
120	6	6	4	12	15	13	8	25	25	22	15	45
140	8	7	4	14	18	15	10	30	30	26	17	52
160	9	8	5	16	20	17	12	34	34	30	20	60
180	10	9	5	18	23	20	13	38	38	33	22	67
200	11	10	6	20	25	22	15	42	42	37	25	75
250	14	12	8	25	32	28	18	53	53	47	31	93
300	17	15	9	30	38	33	22	64	64	56	37	112
350	20	17	11	35	45	39	26	75	74	65	43	130

*These times are possible only if some means of absorbing the carbon dioxide is provided.

Air Filter

All mechanically ventilated shelters should be equipped with the usual type of air filters in order to keep out the usual atmospheric dusts and any dust caused by explosions. Experience in Spain during their civil war showed that a number of air raid shelters were put out of operation because the dust from nearby explosions entered the filtering system and stopped up the gas filters.

Gas Filters

From the viewpoint of the ventilating engineer the poison gases used in war may be divided into two classi-

Fig. 3. Entrance to an air raid shelter in Sydney, Australia. This type of shelter is designed primarily to protect the occupants against shell splinters and not against direct hits.

fications. True gases, such as chlorine, chlorpicrin, phosgene, mist clouds such as mustard gas and Lewisite, and smoke clouds such as sulfurtrioxide and diphenylchlorarsine.

Smokes and mists are quite frequently used in gas attacks since they make it possible to infect the ground and also tend to clog up the carbon beds used in poison gas filters. Therefore, in order to provide complete safety against the known gases it is necessary to install a filter which will remove not only the poisonous gases but also the smoke particles. Such a unit should consist of a filter which will remove atmospheric dust and dirt, a secondary filter which will remove the extremely fine poison smoke clouds, an activated carbon bed for adsorbing poisonous gases and a bed of hopcalite which will absorb the carbon monoxide liberated by ordinary bombs. Usually all or most of the substances are incorporated in a device known as a collective protector. This device is quite similar to the canister used on gas masks. The filters for removing the poisonous smokes, as stated previously, must have the ability of removing extremely fine particles since the particles making up poisonous smokes have an average diameter of less than one fourth of a millionth part of an inch. Many materials have been employed in these filters including felt, special papers and cardboards, a mixture of Merino wool and asbestos and in one case a mixture of asbestos elements especially treated, cotton wool impregnated with a chemical and an absorbent corrugated paper filter.

Activated carbon is used for absorbing the poison gases in practically all known filters mainly because of its ability to remove war gases and for its low affinity for water.

There are two basic types of filters in use at the present time. One, the bed type, and the other, a canister type. The bed type consists of a single bed of activated carbon together with the necessary filters for removing

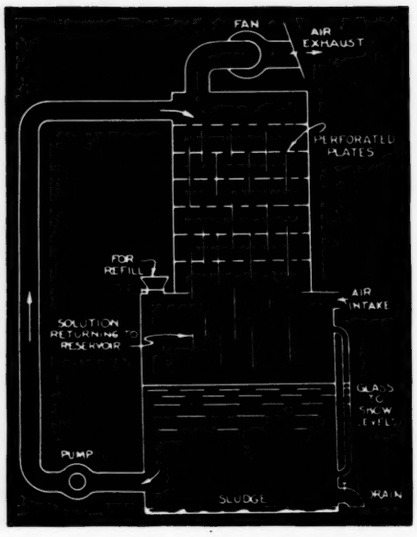


Fig. 4. Cross section of apparatus which might be used for absorbing carbon dioxide in unventilated shelters. This device uses dilute solution of caustic soda to absorb carbon dioxide. It is similar to equipment used in food storage rooms for controlling the carbon dioxide concentration.

dusts and smoke clouds. The disadvantage of this bed type filter is that it has a relatively high resistance and it may pass poison gas if the density of the activated carbon is not uniform over the entire surface.

The canister type is made up of a number of small canisters, each a complete filter in itself. Because of the much larger surface in this type of filter the air resistance is much lower than for the bed type and at the same time there is no danger of some of the air passing through without the gas being removed. In the canister type filter each of the canisters is usually made up of a filter which is designed to take out the larger dust particles, a filter designed to remove the smoke clouds, and finally the activated carbon filter.

It is important that the activated carbon bed be kept dry since if it becomes damp it may release some of the poison gases after it has been in use for some time. Therefore when the filter is not in use the inlet and outlet valves should be kept closed.

It is extremely important to have a collective protector with a low resistance, since during the air raid the electric current may be shut off making it necessary to use human power for forcing the air through the filter.

In designing the shelters the collective protector should be installed outside of the protected space and the air should be drawn through it rather than forced through. This is done so that in case there is a leak in the unit it will still be effective and the air will not become contaminated.

Auxiliary Equipment

A number of auxiliary pieces of equipment must be included in the ventilating system. These consist of such devices as the gas filter by-pass including gas valves, heavy ductwork, exhaust or pressure relief valves for allowing the exhaust air to escape from the shelter and intake connections and valves. It is quite important, of course, that all the valves be gastight and it is usual practice to make them either of the sliding or swinging type. Figs. 10 and 11 show a sliding type and a swinging type valve respectively. The latter illustration shows a swinging type valve hooked up so that it may be driven by a motor in case it is not in a convenient location for hand operation.

The exhaust valves are provided to prevent the poison gases from leaking back into the shelter during a period of outside high pressure due to an explosion. These valves are built so that they maintain somewhere between ¼ and ½ in. of static pressure inside the shelter. This serves to prevent any infiltration of poison gas. Figs. 8 and 9 show two typical valves, one a ball type and the other a swinging type.

The air intake, through which all

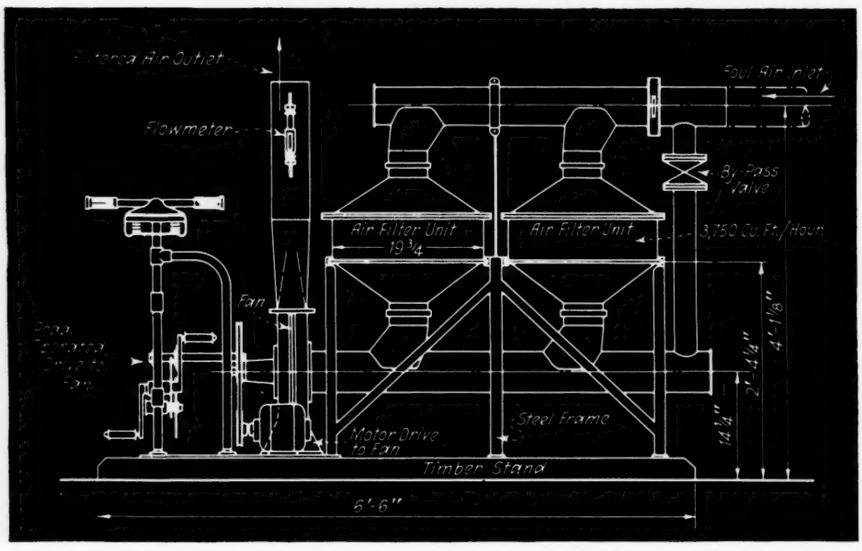


Fig. 5. Typical air raid ventilating unit which is designed to filter poison gases from the ventilation air. This unit is designed to take care of the needs of a shelter housing 50 persons.

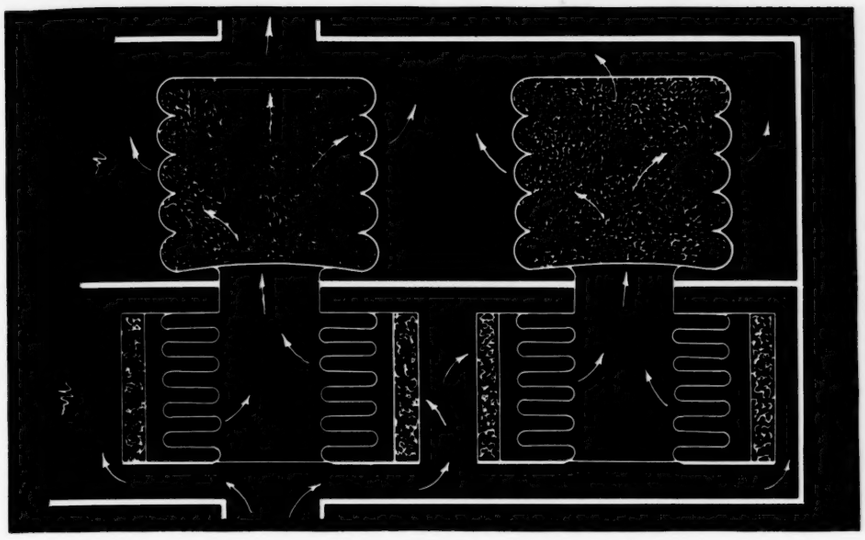


Fig. 6. Cross section of part of a canister type poison gas filter. Air enters through an opening in the bottom, passes through a filter which removes ordinary atmospheric dusts, then passes through a corrugated special filter which is designed to remove poison smokes. Finally it is drawn through an activated carbon filter which adsorbs the poison gases themselves.

outside air is drawn, should be so located that it takes the air from a position at least 30 ft above the ground and at least 10 ft over the nearest roof. If this is done even during a poison gas attack only low concentrations of poison gases will be drawn in because practically all of the gases employed are heavier than air and sink to the ground.

It is very important that these air intakes be provided in duplicate so that in case one is destroyed there will be some means of bringing air into the shelter. Some authorities point out that these air intakes should be made of cast iron pipe rather than wrought iron or sheet iron since when cast iron pipe is subject to shock it will break cleanly and will usually, even though it is partially destroyed, allow air to pass through it. Wrought iron or sheet metal ducts may be collapsed by any nearby explosion thus shutting off or restricting the air supply.

Ductwork in the shelter, particularly that handling the outside air, should be of relatively heavy construction so that it will not be damaged by pressure waves from nearby explosions. All dampers should also be of heavy construction for the same reason.

HEATING AND COOLING

In most shelters in the United States the problem of maintaining comfortable conditions is a problem of cooling rather than of heating, though occasionally it may be desirable to employ some form of heating. Shelters which would require heating are those which are continuously occupied by a relatively small number of people, shelters which are not below the ground, and mechanically ventilated shelters in the cold part of the country where the air temperatures might get to zero or below. It has been found in Europe that if the air is introduced at a temperature much below 60F uncomfortable conditions will be produced in the shelter due to the cold air falling to the floor. For this reason it is desirable to limit the inlet air temperatures to 60F.

A big problem in heating is to find a satisfactory source of heat. Practically all shelters in Europe employ some form of electric heat, although it is realized that this is not entirely satisfactory because of the danger of failure during air raids. However, since there are no fumes and since the units are relatively inexpensive electric heating seems to be the most satisfactory solution to date. Where heat is to be supplied directly to the shelter the usual practice has been to employ electric unit heaters which are equipped with fans. This serves two purposes, to heat the air and to circulate it. It has been estimated that in this country unit heaters should have an air capacity of 200 cfm and an electric capacity of 2.5 kw for rooms up to about 30 or 40 ft long. The general wattage under average conditions for surface structures has been taken as 1.5 watts per cu ft with 0.5 kw for each 100 cfm of outside air. For underground shelters in buildings the wattage loading is taken as 1 watt per cu ft while for outside underground structures it is taken as 1.5 watts per cu ft.

In some cases where steam or hot water is available a radiator may be placed in the shelter. However, when this is done the piping should be kept as short as possible and a quick type shut-off valve should be installed at the point where the pipe enters the shelter so that the heat can be shut off in case the pipe is broken during a raid.

Fig. 7. A proposed steel house for defense workers which offers some protection from bomb splinters.

Cooling

The Office of Civilian Defense has pointed out that in large shelters which are equipped with an independent power plant it might be desirable to install air cooling refrigerating equipment. If this equipment were installed it would be possible to reduce the floor space per person to 6 sq ft. They state that such a cooling system must be of ample capacity to take care of approximately one-half the total heat given off by the people in an underground shelter or three quarters of the heat given off in an above ground shelter. This will require, according to their estimates, about 1 ton of refrigeration for each 50 people underground or 1 ton for each 33 persons above ground with a minimum of 6 sq ft of surface per person and with the walls, floors and ceilings constructed of uninsulated concrete. Under these conditions a shelter housing 500 persons would require 6.7 tons of air cooling.

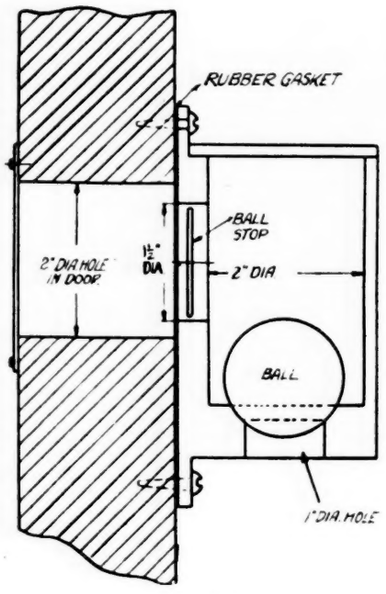


Fig. 8

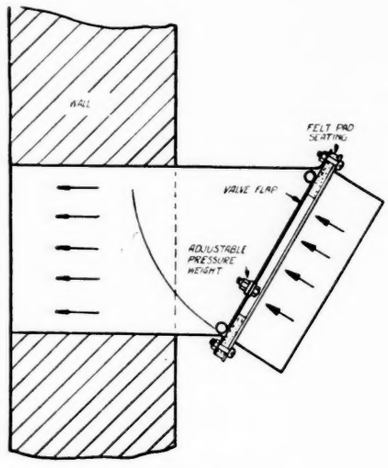


Fig. 9

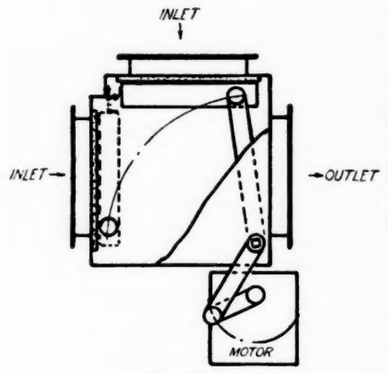


Fig. 10

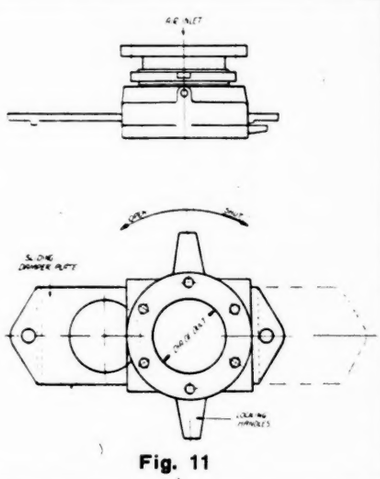


Fig. 11

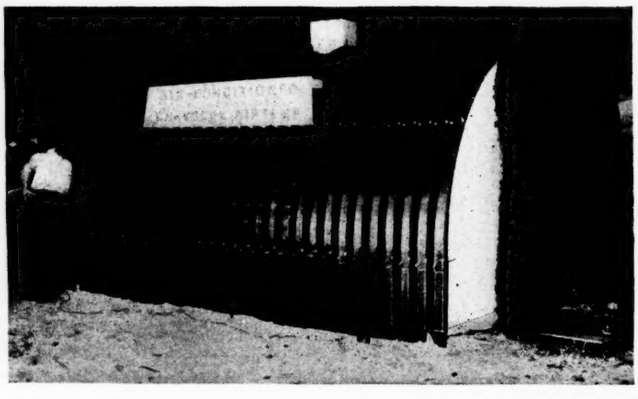
Figs. 8 and 9 show two types of relief valves which are designed to allow the exhaust air to escape from the shelter and to prevent any outside air from entering through these openings. Fig. 8 shows an all-check valve while Fig. 9 shows a swinging type valve. These valves are used in design to maintain pressures up to ½ in. static in a shelter. Figs. 10 and 11 show a swinging type and sliding type intake valve which are placed on the air inlet connected to the shelter. Both of these valves are quick acting and gas tight.

SUMMARY

From the foregoing discussion it can be seen that the most desirable type of shelter is the one using mechanical ventilation. It has the advantage that it gives positive protection against all known war gases, it gives the best conditions from the standpoint of health and comfort and at the same time will probably not cost much more than the unventilated structures because it is possible to make the ventilated shelters much smaller than unventilated ones.

The type of shelter constructed, however, will depend largely on local conditions, on materials available, and on the number of occupants to be housed. Before the best shelter for any given set of conditions can be selected, careful study will be needed. In all probability, however, should the Government deem it advisable to construct large numbers of shelters, several standard designs will be offered which will meet most civilian requirements.

A limited number of reprints of this 16-page section on air raid shelters (H & V Reference Section No. 3) are available at 25 cents each from HEATING AND VENTILATING, *148 Lafayette Street, New York, N. Y. Previous reference sections in this series are still available at 25 cents. These are H & V Reference Section No. 1 on Radiant Heating, and H & V Reference Section No. 2 on Underground Steam Piping.*



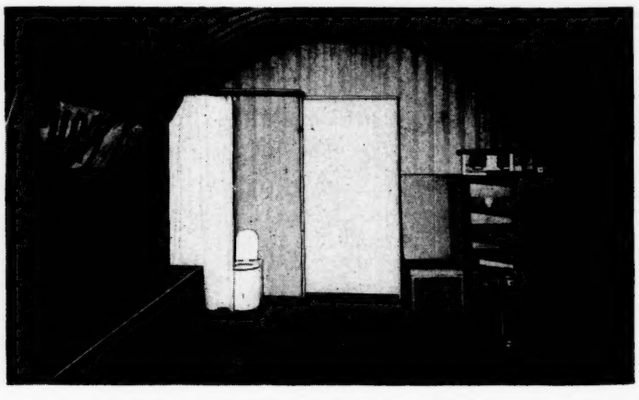


Fig. 12. Two views of one of the first air conditioned bomb shelters exhibited in the United States. Shelter was built of steel and is equipped with a 3 hp Airtemp air conditioning unit. The shelter is built of 7 gauge corrugated steel and is designed to be placed at least 3 ft below the earth's surface. Stack at center shows air intake.

WASHINGTON NEWS

summarized by Loring F. Overman. Limitation order on Air Conditioning. A.C. and Heating under new W.P.B. Announcement from Timmis on Repairs.

What effect will Donald Nelson's newly created War Production Board have upon the heating and ventilating industry?

The answers to this question will influence the lives of thousands of men, women, and even children who look to this industry for their livelihood.

As HEATING AND VENTILATING goes to press the answers are still indistinct, but the pattern is clarifying. It seems inevitable that the heating and ventilating industry, along with hundreds of others, will be measured by the following yardstick:

"Is it *essential* to Victory?"

To some the yardstick of essentiality may cast an ominous shadow, but to the industry as a whole the growing tendency — perhaps Nelson-inspired — to view the Victory program as a unit rather than piecemeal, is of tremendously favorable significance.

While individual interpretations of such a policy still leave much to be desired, there appears to be an increasing disposition on the part of priorities officials to consider the word *essential* in terms more relative than specific. Although "More Planes, More Guns, More Ships" is still the goal, the question of allocating a given carload of metal seems to be involving broader considerations.

Admittedly, the carload of metal would produce one tank, or half a dozen howitzers—but would the same amount of metal, in an air conditioning unit, step up the production of a blast furnace; increase the efficiency of workers fabricating *many* tanks, or increase the output of an entire factory making shells?

Officials within the priorities division are not yet ready to be quoted on this trend, but it is definitely apparent. As voiced by one official:

"If there's a ton of extra metal available and we must choose between one gun for the army or one compressor unit to protect recurring shipments of food, it isn't difficult to see that protection of that food is as important to victory as is the gun itself. This would be doubly true if spoilage of the food made it impossible to feed the men who were to have manned the gun."

It was the hope of the President, in appointing Nelson as chairman of WPB, to encourage over-all planning for all-out victory. If the new trend is indicative of things to come, the sacrifices which some segments of the industry must make on the altar of essentiality will be quickly offset when Victory permits resumption of normal business. Unlike the automobile industry and others having to convert their *entire* production to materiel unnecessary to peacetime economy, the heating and ventilating industry will enter the postwar period backed by records of industrial efficiency that will open vast new fields for exploitation of air conditioning as an essential.

Limitation Order Expected

A limitation order attempting to define essential and non-essential units of air conditioning and refrigeration will be one of the initial steps taken by the War Production Board's new section assigned to this field. Roughly speaking, units of less than 10 tons capacity will be subject to the heaviest restrictions, with units of more than 10 tons most likely to be classified as essential. Wherever construction of the smaller units involves the use of scarce materials, their manufacture will be definitely discouraged.

Preliminary surveys of probable requirements under this policy indicate it may even be necessary to expand the industry's capacity to produce the larger units, either through additional facilities or through subcontracting of parts to manufacturers normally engaged in the production of small units. Where this subcontracting is impracticable there appears only one alternative for the manufacturer of small equipment — conversion of part or all of his facilities to the manufacture of military requirements.

WPB Lineup Announced

Not all details as to the functioning of the new War Production Board under Donald Nelson are clear, but observers here are of the opinion that the structure will not be markedly different as to departments or personnel from the abolished OPM and SPAB. The reorganization has been designed with a view to more clearly defining responsibilities, and Chairman Nelson has indicated that this interim set-up will undergo further modifications to meet changing conditions.

W. W. Timmis, Chief of Plumbing and Heating Section, W.P.B.

Direct operation divisions are seven units, of which the only new creation is the Division of Industry Operations, headed by J. S. Knowlson, Stewart-Warner president. Under this unit are the industry sub-divisions, including Air Conditioning & Refrigeration and Plumbing & Heating.

Air Conditioning and Refrigeration Branch

Philip D. Reed, chairman of the board of directors of General Electric Company, will head the industrial branches in the Division of Industry Operations of WPB, while the head of the Air Conditioning and Refrigeration section of the Consumers' Durable Goods branch will be E. H. Hammersley.

Assisting Mr. Hammersley will be Sterling Smith, formerly eastern division manager, contact division. Kelvinator Corporation, and Roderick Tait, president of R. N. Tait & Sons, St. Louis, air conditioning distributors. Mr. Smith will be assigned to units up to and including 25 tons' capacity, with Mr. Tait in charge of contacts involving larger units.

All applications for priority assistance involving construction of air conditioning and refrigerating equipment will pass through Mr. Hammerley's section. It is expected that control of Freon will soon be assigned to this section.

Industry Committee Formed

An Air Conditioning and Refrigeration Industry Committee has been formalized and a meeting is to be called early in February to discuss the

pending limitations order and a new repair and maintenance order being prepared. Two previously called meetings of the Industry Committee have been postponed because of intervening WPB developments, but it is expected that the next call will find all in readiness for an announcement of 1942 requirements and an assignment of a Victory program to the industry.

Plumbing and Heating Branch

Under the WPB set-up, W. Walter Timmis is chief of the Plumbing and Heating Branch of the Industry Operating Division. Assistant chief is Laurence S. Knappen. The following are chiefs of sections: L. W. Smith, Jr., fixtures and specialties; J. Brice Hungate, pipe, valves, fittings; Harwood Otto, simplification; David H. Butler, heating; Joseph T. Kelly, wholesalers, and John F. Steele, program. George C. Hench is the liaison man for the branch.

Mr. Timmis, who has been president of Au-Temp-Co Corporation of New York and vice-president of Herske and Timmis, Inc., at one time was manager of American Radiator's air conditioning systems and control division. Mr. Knappen was a member of the economic staff of Rutgers University and the author of a number of books on economics and finance. L. W. Smith, Jr., the originator of the Committee of Ten, Coal and Heating Industries, at one time was with Minneapolis-Honeywell Regulator Co., and more recently director of the General Electric Kitchen Heating Institute. Mr. Hungate has had a wide experience with pipe manufacturers and jobbers. Mr. Butler was for 16 years with the Iron Fireman Co., while Mr. Steele, a contractor and construction engineer, was a member of the Harvard Business School faculty and later market research analyst for large corporations. Since last fall he has been working under the chief of the petroleum section in the Office of Petroleum Coordinator Ickes.

An Industry Committee also awaits a call to an early February meeting planned by this branch, and early assignments for sub-committees in each of the sections are contemplated. As in the Air Conditioning and Refrigeration Section, the meeting call will be issued as soon as surveys of the Victory Program's requirements are better known.

Production Requirements Plan Important

Mr. Timmis has requested HEATING AND VENTILATING to call attention to the importance of taking immediate advantage of the priority assistance offered by Suppliers' Order M-67. Mr. Timmis' letter follows:

"The Government has recognized that repair and maintenance of plumbing and heating are essential. In the Production Requirements Plan (for manufacturers) and in Suppliers' Order M-67 (for wholesalers and dealers) a plan has been devised for the production and equitable distribution of plumbing and heating supplies to be used for the repair and maintenance of homes, farms, retail stores, and commercial concerns.

"While the Production Requirements Plan and Order M-67 may be supplemented by other measures, they now constitute an informal repair and maintenance plan for plumbing and heating.

"M-67—an inventory control measure—depends for its success upon the prompt and full cooperation of manufacturers in the Production Requirements Plan. Manufacturers should fill out and submit *without delay* their copies of PD-25A. The ability of wholesalers and dealers to obtain inventories of repair and maintenance items hinges upon the quick response of manufacturers to this request. The work of the Plumbing and Heating Branch of the War Production Board will be greatly hampered if we do not receive the quick and whole-hearted cooperation of manufacturers.

"Your action in bringing speedy news of the repair and maintenance plan to the plumbing and heating industry will be a real service. Your continuing cooperation in urging manufacturers to submit PD-25A will be of great help to this Branch, and will assist the war effort in which we are all engaged.

Very truly yours,
W. WALTER TIMMIS, *Chief*
Plumbing and Heating Branch,
War Production Board"

It is suggested that retailers and manufacturers desiring additional information concerning the plans mentioned, or copies of the necessary forms, write to the Plumbing and Heating Branch, War Production Board, Washington, D. C.

Asbestos Placed Under Control

South African asbestos has been placed under strict priority control under Conservation Order M-79. The order prohibits the use of South African asbestos after February 1, except to fill defense orders, and then only for specified purposes.

"Unless specifically authorized by the Director of Priorities," says the Order, "after February 1, no one shall process any Chrysotile asbestos fibre unless necessary to fill defense orders for core roving or non-ferrous tapes, cloth and lapps."

Prohibitions are also placed on processing Grade B-1 amosite asbestos fibre except to fill defense orders for woven felt blankets and mattresses for marine turbine insulation. Nor shall anyone process Grade B-3 or D-3 amosite asbestos fibre unless to fill defense orders for turbine insulation blankets, fireproof board, sprayed amosite, welded amosite pipe covering and blacks, 85 per cent magnesia pipe covering, flexible amosite pipe insulation or dry pack insulation. The order prohibits installing without specific authority any high temperature pipe covering unless used where temperatures of over 200 degrees fahrenheit occur.

Oil Price Ceiling Nears

Prices for petroleum and petroleum products now generally effective as a result of OPA requests and voluntary agreements with members of the industry will be incorporated into a formal price schedule in the near future, according to Leon Henderson, Administrator of the Office of Price Administration.

In addition to setting maximum prices for petroleum and petroleum products generally, the price schedule will make provisions to cover the special situation in 15 Eastern and Southern States and the District of Columbia, where recently a 3/10 cent per gallon increase in gasoline was permitted because of increased carrying charges incurred by producers to avert a gasoline shortage due to diversion of tankers to war and lend-lease use.

Exceptions will be made to cover the Bunker C and Grade 6 fuel oil prices on the Eastern Seaboard and Gulf Coast, recently established in a Price Schedule.

The Construction Outlook

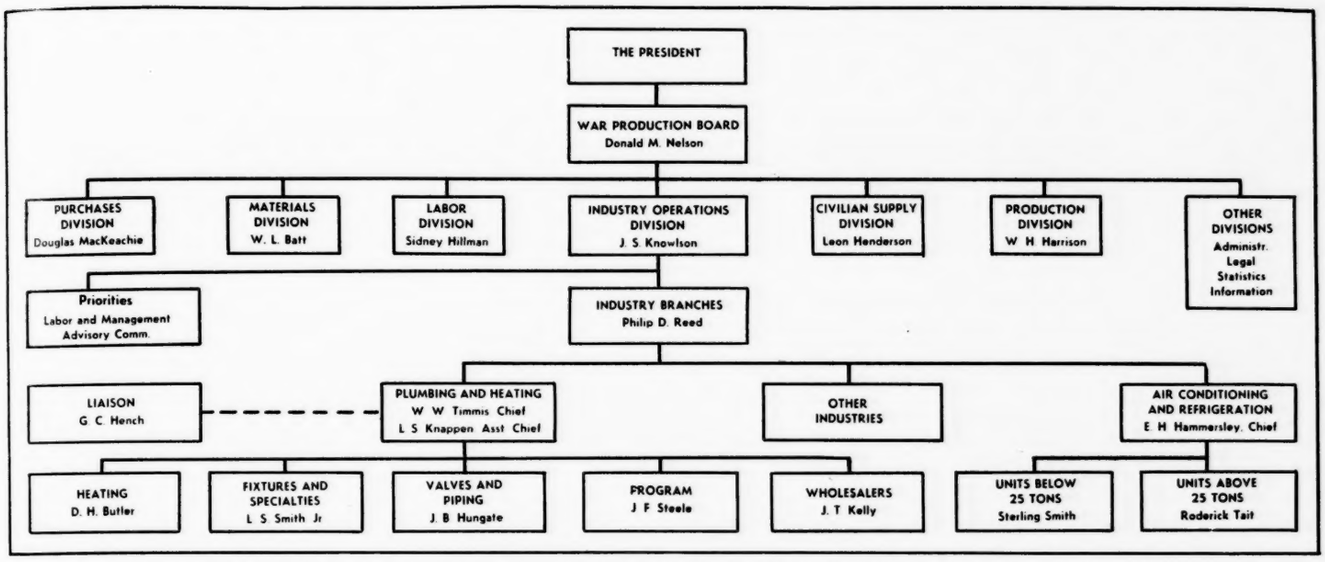
Although the President signed, on January 21, a defense housing bill providing $450 million in added appropriations for housing and community facilities in defense areas, it is unlikely that construction for 1942 will equal that of 1941. Considerable additional cantonment construction is planned, as well as additional plant facilities, but it is expected these increases will be more than offset by losses in other types of building.

Censorship Challenges Ingenuity

Since defense installations promise to represent the bulk of the outlets for heating, ventilating and air conditioning equipment for some time to come, recent censorship regulations applying to announcement of intended construction projects offers a challenge to alert suppliers. Firms or individuals desiring to bid on defense installations must now make doubly certain their names, as interested bidders for either prime or sub-contracts, are in the files of all Government purchasing offices.

Defense Housing Materials Require Priority

Manufacturers supplying materials for defense housing projects must hereafter apply for priority assistance under a recently announced Production Requirements Plan. The plan is a simplified scheme under which approved production may be granted



Organization chart of the War Production Board insofar as it directly affects the heating and air conditioning industry. Names are of the heads of divisions or branches.

priority ratings which will assist a producer in obtaining required materials for three months at a time.

This change in the procedure on defense housing projects is provided for in connection with an amendment to Preference Rating Order P-55, issued January 12 by the Priorities Division.

Under the former procedure, manufacturers of building materials could extend project ratings to speed up their own purchase orders for necessary materials. Under the new procedure, however, these manufacturers may not extend the ratings assigned to the project, but will apply on form PD-25A for assistance.

When a rating has been applied to a housing project, that rating may be extended by a builder to a supplier if the supplier has not "in whole or in part manufactured, produced, assembled or otherwise physically changed" the materials to fill a rated order. The rating carried by the project may be applied by the supplier to his own purchases, but when the rating has been extended as far as the manufacturer, he must apply for assistance under the Production Requirements Plan. The manufacturer is not to extend the project rating directly.

Lend-Lease Requests

There have been cloak-room rumors in Washington about British purchases of champagne and other luxury items under Lend-Lease terms—and hearty denials. At any rate, the Air Conditioning and Refrigeration Section of WPB isn't planning on bending over too far backward in honoring overseas requests for priorities on equipment that will doubtless be denied American civilian buyers.

Recent South American Lend-Lease priority requests involving room coolers, water coolers and other small refrigerated units that seem slated for curtailment in this country are being held up on the theory that if Americans have to give up such items in the interest of Victory, the Good Neighbors can do likewise.

Nickel Controlled

After April 1, nickel cannot be used in the manufacture of most building supplies, hardware, or plumbing and heating equipment. A list of items on which nickel cannot be used can be secured through the War Production Board, Washington, D. C.

Lewis in Ordnance

Thornton Lewis, 1929 president of the ASHVE, and formerly executive vice president of the Carrier Corporation, has been appointed chief of the Industrial Service Production division of the Ordnance Department, and has taken over his new duties at Washington under Gen. L. H. Campbell, Jr.

As chief of the Production section, Mr. Lewis becomes the No. 1 civilian employee of an Ordnance Department organization charged with the responsibility of producing all munitions required by the Army. Ammunition, small arms, artillery, tank and combat vehicles, and arms for aircraft are included.

Mr. Lewis brings to his position a wide knowledge of production methods and of the facilities available to produce the thousands of components required for the manufacture of military equipment.

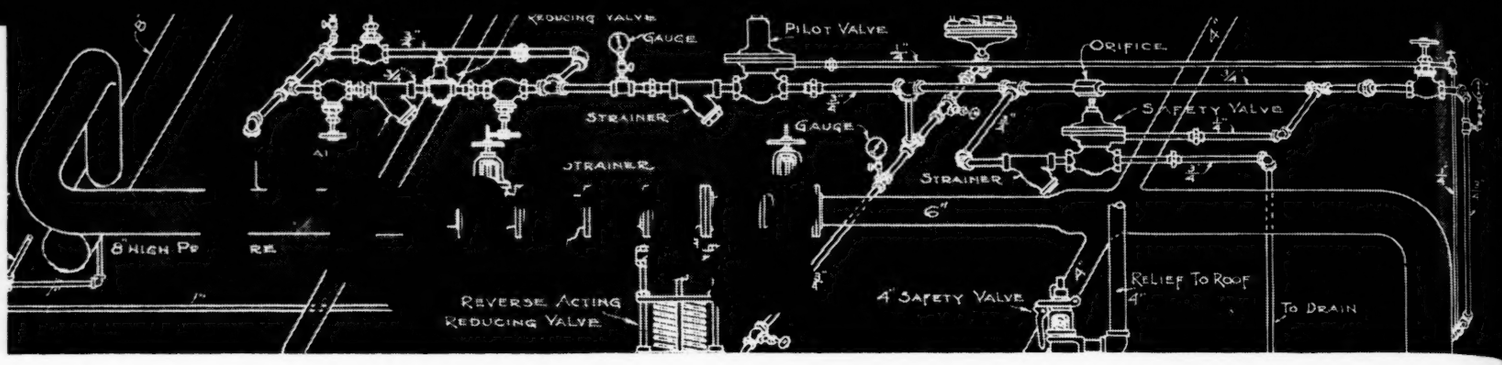
"Our main task is to break any bottlenecks that may be interfering with the production of the Ordnance quotas," said Mr. Lewis. "Several in the heating and air conditioning industry are already assisting in this program, and others will be called upon as the program progresses. Some will be assigned the production of the vast quantities of heating and air conditioning equipment required to make ordnance facilities operate at maximum efficiency. Others will be called upon to convert their facilities to military production with all possible speed."

Gas Heat

As Heating and Ventilating goes to press, reports indicate that a new complete priority control prohibiting further installations of gas heaters in all but Southeast states is expected.

IN THE WASHINGTON LIMELIGHT

J. S. Knowlson *L. S. Knappen* *R. Tait* *W. S. Hammersley* *S. Smith* *T. Lewis*



16 Steps in Sizing Piping for Cold and Hot Water Supply

A difficult problem in the design of hot or cold water supply in buildings is the selection of the most economical pipe size that will assure adequate water supply at all outlets at all times, and at the same time be satisfactory not only when new but in years to come when the capacity of the piping is decreased by deterioration.

As part of its program of research on building materials and structures, the National Bureau of Standards has investigated this phase of design and in each of three of its recent publications has presented, under the authorship of Roy B. Hunter, an important collection of data on this subject together with a method of calculating pipe sizes developed from the author's application of the probability function to demand by intermittently operating fixtures, an analysis of various pipe flow formulas from which he prepared four flow charts, and a method of applying all these and other data.

Since heating engineers are only too frequently concerned with water pipe sizing, and since the data, explanations, and method of applying are somewhat scattered, and for this reason somewhat difficult to follow, HEATING AND VENTILATING has condensed the actual application of the data to the step-by-step method presented in the article which follows. Credit for the method itself is due the Bureau and Mr. Hunter; on the other hand they are not responsible for our interpretation of the method.—EDITOR.

THE selecting of pipe sizes for hot and cold water supply systems in buildings involves the following procedure:

A. Estimating the probable maximum demand on the mains and branches;

B. From the layout of the building and fixture locations, determining the equivalent length of the different parts of the system;

C. Estimating the pressure available for friction loss in the system, first having determined the minimum pressure in the street main or other source of supply, difference in static head between the street main and highest fixture, minimum allowable pressure at the highest fixture, and friction loss through the meter;

D. Selection of the kind of pipe — steel, wrought iron, copper or brass — depending on the effects of the local water on each and consequent life and capacity together with cost of each kind.

E. Selection of the proper flow formula or flow chart, depending on the kind of pipe and effect of the water on it;

F. Selection of the pipe size from the formula or flow chart, beginning with the main and on through each riser and branch.

In this article each of these will be taken up step by step, followed by an example to indicate how the method is applied to an actual case.

The peak demand of any given fixture is only too easy to determine by simple tests. The problem is, and has been, to determine the maximum demand of the system. By applying the probability theory to the problem and by making certain assumptions, it is possible to arrive at the probability of a certain number of fixtures operating simultaneously at any given instant. The maximum demand on the system then becomes a matter not only of how many of these fixtures will operate simultaneously but also of taking into account the relative demand of each. In the method presented here, each type of fixture has been assigned a fixture weight; for example, a private lavatory has a weight of 1 and a private water closet with flush tank a weight of 3. This means that the latter will, on an average, require three times the flow of the former, for purposes of these calculations.

Knowing the total number of weighted fixture units, the total demand in gallons per minute is determined by reference to suitable curves.

Tables 1A and 1B give the demand weights of fixtures in fixture units. Table 1A is devoted to public occupancy buildings, such as office buildings; the word *public* is applied here as meaning fixtures individually

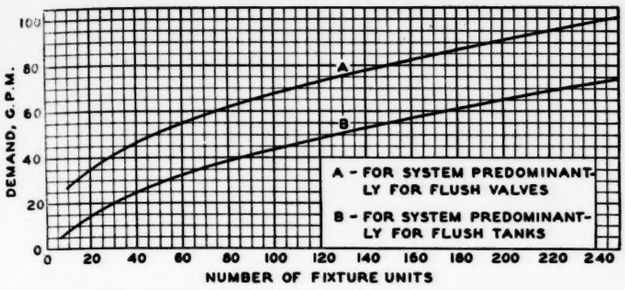

DEMAND, G.P.M.
NUMBER OF FIXTURE UNITS
A - FOR SYSTEM PREDOMINANTLY FOR FLUSH VALVES
B - FOR SYSTEM PREDOMINANTLY FOR FLUSH TANKS

Fig. 1. (Above) Chart for determining the estimated maximum demand of intermittently operated fixtures based on the number of fixture units when the number of fixture units is less than 240.

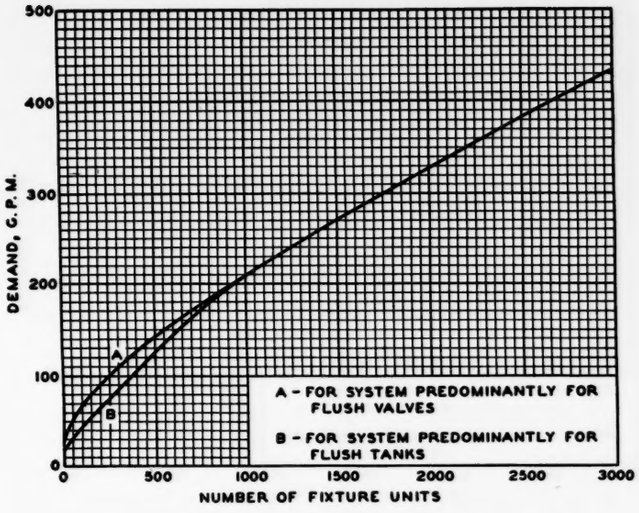

DEMAND, G.P.M.
NUMBER OF FIXTURE UNITS
A - FOR SYSTEM PREDOMINANTLY FOR FLUSH VALVES
B - FOR SYSTEM PREDOMINANTLY FOR FLUSH TANKS

Fig. 2. (Right) Chart for determining the estimated maximum demand of intermittently operated fixtures based on the number of fixture units when the number of fixture units is over 240.

open at all times when the building is open, as in public buildings and office buildings. *Private* refers to fixtures in groups installed so that the entire group may be and generally is confined to the use of one person at a time, as in residences, apartments, or private baths in hotels. The word *total* in these tables refers to hot and cold supply combined. *Hot or cold* refers to hot or cold supply only.

Since flush tank water closets have a lower maximum demand than flush valve fixtures, two curves are presented for determining the total maximum flow once the fixture weights are totaled, as shown in Fig. 1. In the lower region, the upper curve is for systems predominantly of flush valves, the lower for systems principally of flush tanks; in the upper region the two curves merge and become one. Fig. 2 is a section of the lower portion of Fig. 1 on an enlarged scale, presented here for greater ease and accuracy of use when the fixture units total less than 240. To use these graphs, enter at the horizontal scale and move vertically to the intersection with the proper curve, then follow horizontally to the scale showing demand in gallons per minute.

The purpose of Figs. 1 and 2 is to estimate the maximum demand of the (briefly) intermittently operating fixtures only. Devices or fixtures which impose a relatively continuous demand of water — such as garden hose outlets, air conditioning apparatus, and the like —are to be taken into account and added *after* referring to the curves. In this connection suggested figures for total demands of *garden hose* connections are:

Number of Outlets	Demand, Gpm
1	5
2	9
3	12
4	14
5 or more	3 gpm per outlet

In small buildings, such as houses and small apartments, there is a great repetition of similar groups of fixtures, so that it is possible to build up tables based on these commonly occurring combination of fixtures, with the objective of saving time and work. Table 2 is such a table which covers some of the cases which will be frequently encountered in this smaller type of installation.

In Table 2 the columns headed Total Fixture Units are from Table 1B, and the columns Total Demand from Figs. 1 and 2.

The purpose in including Table 2 here is merely to illustrate the idea of the user making up his own tables depending on the type of work he does for oft-recurring cases.

TABLE 1A.—DEMAND WEIGHTS OF FIXTURES IN FIXTURE UNITS FOR PUBLIC OCCUPANCY[1]

Fixture[2]	Type of Supply Control	Weight in Fixture Units[3]
Water closet	Flush valve	10
Water closet	Flush tank	5
Pedestal urinal	Flush valve	10
Stall or wall urinal	Flush valve	5
Stall or wall urinal	Flush tank	3
Lavatory	Faucet	2
Bathtub	Faucet	4
Shower head	Mixing valve	4
Service sink	Faucet	3
Hotel or restaurant kitchen sink	Faucet	4

TABLE 1B.—DEMAND WEIGHTS OF FIXTURES IN FIXTURE UNITS FOR PRIVATE OCCUPANCY[1]

Fixture or Group[2]	Type of Supply Control	Weight in Fixture Units[3]
Water closet	Flush valve	6
Water closet	Flush tank	3
Lavatory	Faucet	1
Bathtub	Faucet	2
Shower head	Mixing valve	2
Bathroom group	Flush valve closet	8
Bathroom group	Flush tank closet	6
Separate shower	Mixing valve	2
Kitchen sink	Faucet	2
Laundry tubs (1-3)	Faucet	3
Combination fixture	Faucet	3

[1]For supply outlets which impose a continuous demand, estimate demand and add to the total demand *after* reference to the curve.
[2]For fixtures not listed, assume the weights by comparison to those listed using approximately similar quantities at similar weights.
[3]Given weights are for total demand. For fixtures with both hot and cold water supplies the weights for maximum separate demand may be taken as ¾ the listed demand for the supply.

TABLE 2.—WATER DEMAND FOR TYPICAL BUILDINGS

Type of Building	Kinds of Fixtures			Total Fixture Units		Total Demand	
	Bathrooms	Sinks or Comb. Fixt.	Laundry Trays (1-3)	With Flush Valves for W.C.	With Flush Tanks for W.C.	With Flush Valves for W.C.	With Flush Tanks for W.C.
	Number					G.P.M.	
Small House, no laundry	1	1	0	10	8	27	6
Small House, with laundry	1	1	1	13	11	30	8
2-Bath House	2	1	1	21	17	36	12
3-Bath House	3	2	1	31	25	42	17
4-Bath Flat	4	4	2	46	38	49	24
8-Bath Flat	8	8	3	89	73	64	36
16-Bath Flat	16	16	4	172	140	84	52

All of the foregoing can now be summarized as Steps 1, 2, and 3.

1 By reference to Table 1A if the project is public, Table 1B if the project is private, determine the weight in fixture units for each fixture on the line being calculated. Total these fixture units.

2 If the total from Step 1 is less than 240, use Fig. 2, if greater than 240, use Fig. 1, and, entering the drawing with the total number of fixture units, locate the intersection with Curve A if the closets are predominantly of the flush valve type or Curve B if of the tank type. From the intersection move horizontally to the vertical scale and find the maximum demand of intermittent fixtures.

3 To the figure obtained in Step 2 add the demand (in gpm) of continuous fixtures or devices such as hose outlets, air conditioning apparatus, etc. The total is the total estimated maximum demand.

Subsequent steps are rather simple. Steps 4 to 13 follow:

4 Obtain an estimate of the minimum daily service water pressure; this can usually be found by reference to the water company or department in the particular area.

5 From the plans of the building measure the difference in elevation between the water main and the highest fixture in the building. Multiply this difference, in feet, by 0.434 to reduce it to static head in pounds per square inch.

6 If a water meter is to be installed estimate the friction loss. This can be done by reference to Fig. 3 which applied only to disc-type meters, the type used in most cases. If another type is or is to be installed, the corresponding capacity and head loss data should be obtained.

7 Decide what the minimum pressure should be at the highest fixture for satisfactory operation. This should not be less than 15 lb per sq in. for flush valves or 8 to 10 lb for faucets and flush tanks.

8 Add the static head from Step 5, the water meter loss from Step 6, and the minimum satisfactory pressure from Step 7. This total is the pressure required at the meter entrance if there were no piping friction loss.

9 Subtract the total, Step 8, from the available minimum service pressure, Step 4. The result is the pressure available for friction loss through the piping and fittings.

10 Measure the length in feet of the run of main or branch being calculated. This is a straight measurement from the plans and elevations, if they exist, but do not forget to include the length of the vertical risers which may not appear on the plans.

11 Estimate the equivalent length of fittings in the line under consideration by reference to Table 3. Table 3 applies when the workmanship is reasonably good and to non-recessed threaded fittings. For recessed fittings or streamline soldered fittings, use one-half the values in Table 3.

TABLE 3.—EQUIVALENT LENGTH OF PIPE FOR FRICTION LOSS IN VALVES AND THREADED FITTINGS

Diameter of Fitting, Inches	90° Standard Ell	45° Standard Ell	90° Side Tee	Coupling or Straight Run of Tee	Gate Valve	Globe Valve	Angle Valve
	Equivalent Length of Pipe for Various Fittings, Feet						
⅜	1	0.6	1.5	0.3	0.2	8	4
½	2	1.2	3	0.6	0.4	15	8
¾	2.5	1.5	4	0.8	0.5	20	12
1	3	1.8	5	0.9	0.6	25	15
1¼	4	2.4	6	1.2	0.8	35	18
1½	5	3	7	1.5	1.0	45	22
2	7	4	10	2	1.3	55	28
2½	8	5	12	2.5	1.6	65	34
3	10	6	15	3	2	80	40
3½	12	7	18	3.6	2.4	100	50
4	14	8	21	4.0	2.7	125	55
5	17	10	25	5	3.3	140	70
6	20	12	30	6	4	165	80

12 Add the equivalent length from Step 11 to the actual measured pipe length from Step 10. The result is the equivalent total length of pipe in the line being calculated.

13 Divide the total pressure available for friction loss from Step 9 by the total equivalent length of pipe from Step 12. Multiply by 100. The result is the permissible friction loss per 100 ft of pipe.

The next step involves the selection of pipe. It is not the purpose of this article to deal with this problem excepting insofar as the selection of the kind of pipe affects the sizing.

The capacity of the water system obviously depends on, among other things, the actual diameter of the pipe and the degree of roughness of the pipe. If the water in a given area is such as to cause caking over a period of years, this should be considered, for the caking will not only reduce the actual diameter of the pipe but its degree of roughness will increase, increasing the friction loss.

For the determination of the friction loss, four flow charts are presented, Figs. 4, 5, 6 and 7. Fig. 4 is for use with new smooth copper tubing with streamlined soldered joints, with actual sizes of the types indicated. Fig. 4 can also be used for any correspondingly smooth pipe, such as brass pipe (I.P.S.) with recessed fittings by taking into account any differences in diameter from the diameters shown in Fig. 4. In this connection, Table 4, which gives actual as compared with nominal diameters for different types of piping, is included.

Fig. 5 applies to new wrought iron or steel (fairly smooth) pipe and to actual diameters of standard weight pipe. Fig. 6 is for fairly rough pipe, actual diameters which, in general, will be less in service than the actual diameters of new pipe of the same kind. Therefore, when making close estimates in pipe sizing, it will be necessary to estimate the probable change in diameter in service and to apply a correction.

Fig. 7 is for actual diameters of very rough pipe. Remarks made in the preceding paragraph apply to Fig. 7 as well. If the character of the water is such as to produce a material change in diameter because of corrosion or caking, it is assumed that the pipe should be classified as very rough.

It has been assumed that ferrous pipe (a) after a few years' service with the best of waters will have passed from the fairly smooth (Fig. 5) to the fairly rough (Fig. 6) class and that (b) with service for a few years with badly corrosive or caking water ferrous pipe will pass from the fairly smooth (Fig. 5) to the rough category (Fig. 7).

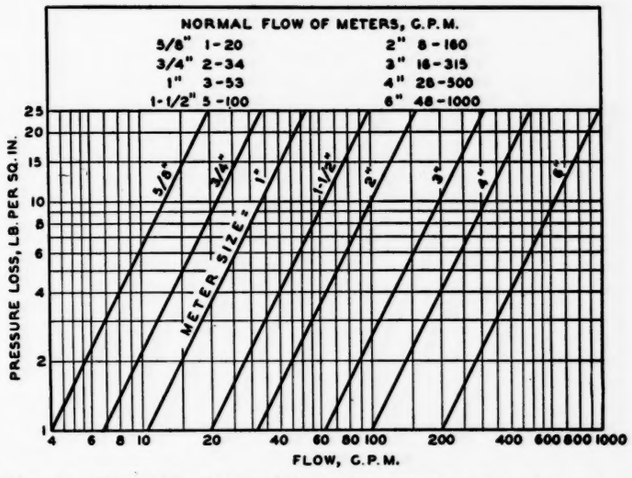


Fig. 3. Chart for determining the pressure loss in water meters. Select the size from the size meters from the table at the top depending on the total estimated maximum flow in gallons per minute. Then enter the lower scale of the chart at the figure representing this flow and move vertically to the line indicating the size of meter selected and opposite the intersection on the vertical scale find the pressure loss.

Ordinarily, with respect to allowances for decrease in capacity, the drop in capacity from caking with hard waters will be relatively greater in (1) the smaller pipe sizes than the larger, and (2) hot water lines than in cold water pipes.

This leads to the subsequent and final steps in sizing:

14 Depending on your selection of kind of pipe and the water available in the area in question, decide which of the flow charts, Figs. 4 to 7, is applicable to your case.

15 Having decided on the proper chart, use Figs. 4, 5, 6 or 7, as the case may be. Enter the vertical scale with the total estimated flow under maximum demand from Step 3. Enter the horizontal scale with the friction loss per 100 ft of pipe, from Step 13. The intersection of the two will indicate, on the diagonal scales, (1) the actual diameter of the pipe to be used and (2) the velocity, in feet per second, of the flow through the pipe during maximum demand.

TABLE 4.—ACTUAL DIAMETERS CORRESPONDING TO NOMINAL DIAMETERS OF DIFFERENT KINDS OF PIPE

Nominal Diameters, Inches	Types of Copper Tubing			Steel or Wrought Iron		Brass (I.P.S.)	
	K	L	M	Standard	Extra Strong	Standard	Extra Strong
	Actual Inside Diameters, Inches						
⅜	0.40	0.43	0.45	0.49	0.42	0.49	0.42
½	0.53	0.55	0.57	0.62	0.55	0.63	0.54
¾	0.75	0.79	0.81	0.82	0.74	0.82	0.74
1	1.00	1.03	1.06	1.05	0.96	1.06	0.95
1¼	1.25	1.27	1.29	1.38	1.28	1.37	1.27
1½	1.48	1.51	1.53	1.61	1.50	1.60	1.49
2	1.96	1.99	2.01	2.07	1.94	2.06	1.93
2½	2.44	2.47	2.50	2.47	2.32	2.50	2.32
3	2.91	2.95	2.98	3.07	2.90	3.06	2.89
3½	3.39	3.43	3.47	3.53	3.36	3.50	3.36
4	3.86	3.91	3.94	4.03	3.83	4.00	3.82
5	4.81	4.88	4.91	5.05	4.81	5.06	4.81
6	5.74	5.85	5.88	6.07	5.76	6.13	5.75

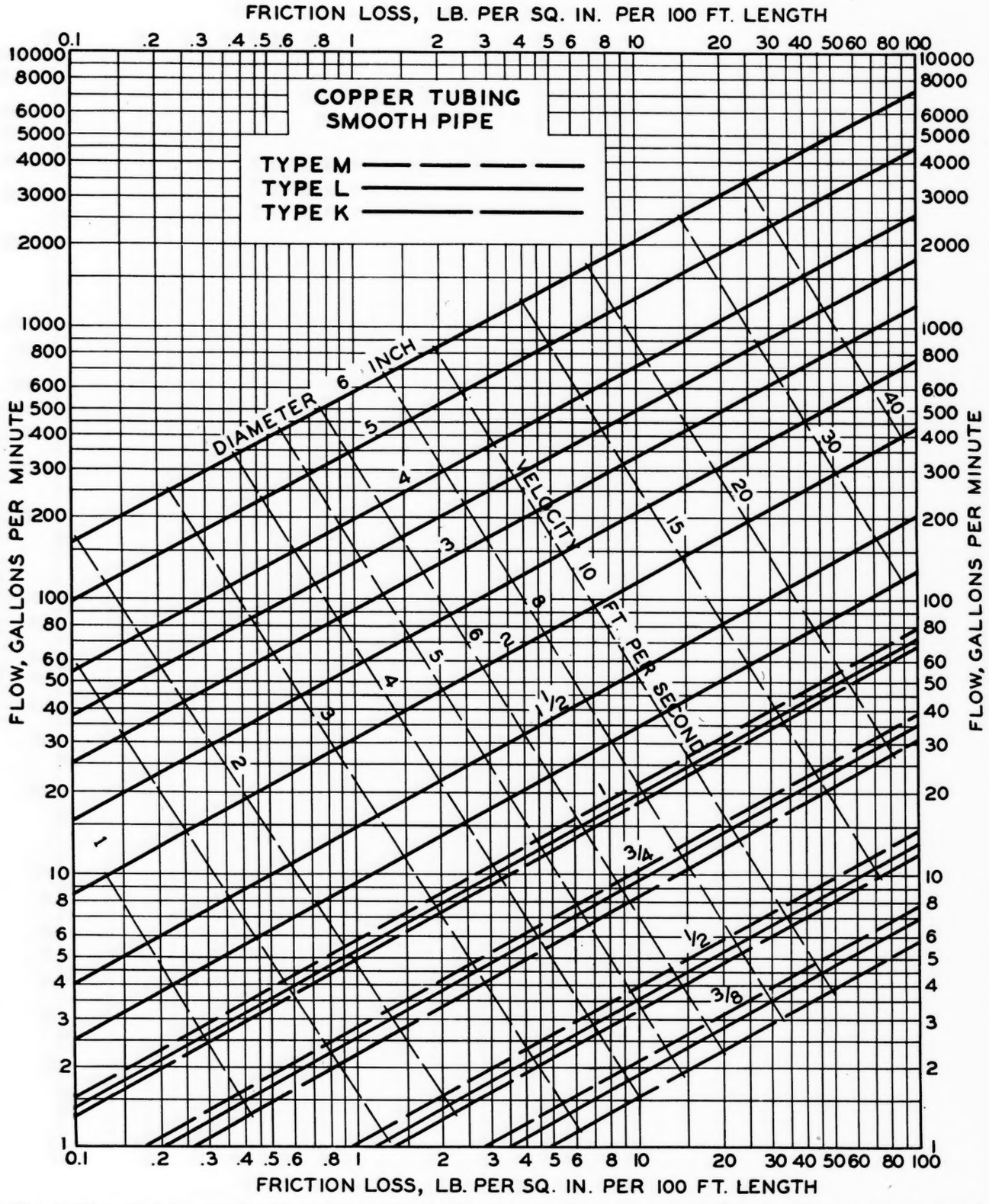

FRICTION LOSS, LB. PER SQ. IN. PER 100 FT. LENGTH
0.1 .2 .3 .4 .5 .6 .8 1 2 3 4 5 6 8 10 20 30 40 50 60 80 100
COPPER TUBING
SMOOTH PIPE
TYPE M
TYPE L
TYPE K
DIAMETER 6 INCH
5
4
3
2
1 1/2
1
3/4
1/2
3/8
VELOCITY 40 30 20 15 10 8 6 5 4 3 2 1 FT. PER SECOND
FLOW, GALLONS PER MINUTE
10000 8000 6000 5000 4000 3000 2000 1000 800 600 500 400 300 200 100 80 60 50 40 30 20 10 8 6 5 4 3 2 1
FRICTION LOSS, LB. PER SQ. IN. PER 100 FT. LENGTH

Fig. 4. Flow chart for smooth pipe such as copper tubing or brass pipe with recessed fittings. The flow for the actual diameters of copper tubing is plotted against friction loss and sizes are given in nominal diameters.

If the diameter falls between two sizes, use the larger. If the velocity is over 15 ft per second use a larger size, as the noise may be objectionable.

16 Using the same friction loss (from Step 13) and the estimated demand load for each branch, determine in the same way the sizes of the branches.

We are now in a position to apply the method to an actual problem of sizing. A main has been chosen for the sake of simplicity.

Example: What will be the size of the water main, to the first branch, supplying an office building with 100 flush-valve water closets, 25 flush valve stall urinals, 100 lavatories, and with an air-cooling system

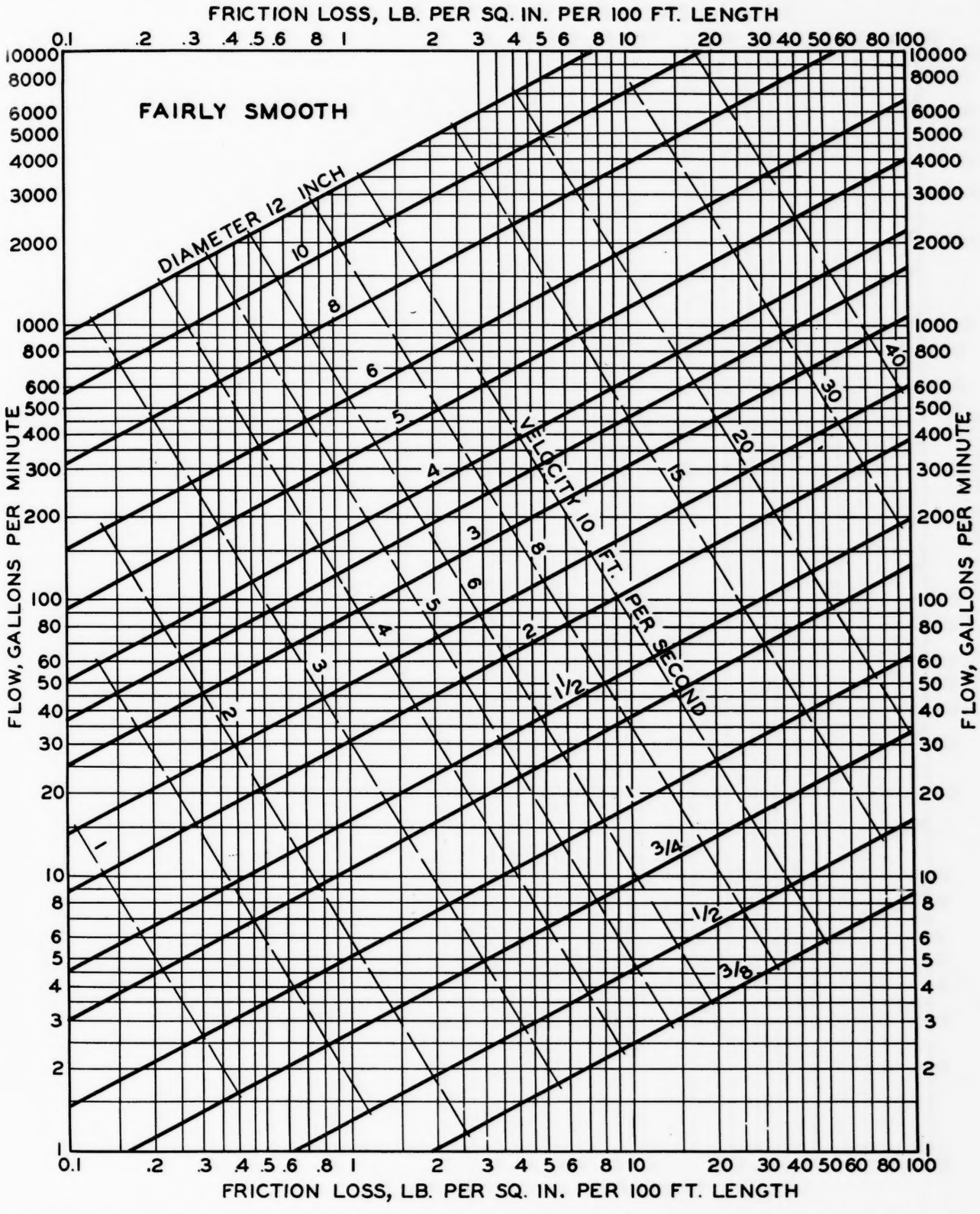


Fig. 5. Flow chart for fairly smooth pipe which applies to any standard weight welded steel or wrought iron pipe. The flow for actual diameters is plotted and sizes are given in nominal diameters.

using 225 gpm? The building is located in a community with a water which cakes badly; steel pipe is to be used, the highest fixture is 30 ft above the meter, service water pressure is 85 lb per sq in., measured length of piping is 840 ft and equivalent length of fittings is 395 ft.

SOLUTION: Step 1. Total fixture units based on Table 1A: $(100 \times 10) + (25 \times 5) + (100 \times 2) = 1325$.

Step 2. Referring to Curve A, Fig. 1, for 1325 units, find 250 gpm.

Step 3. Add to this the 225 gpm for the cooling unit; total, 475 gpm.

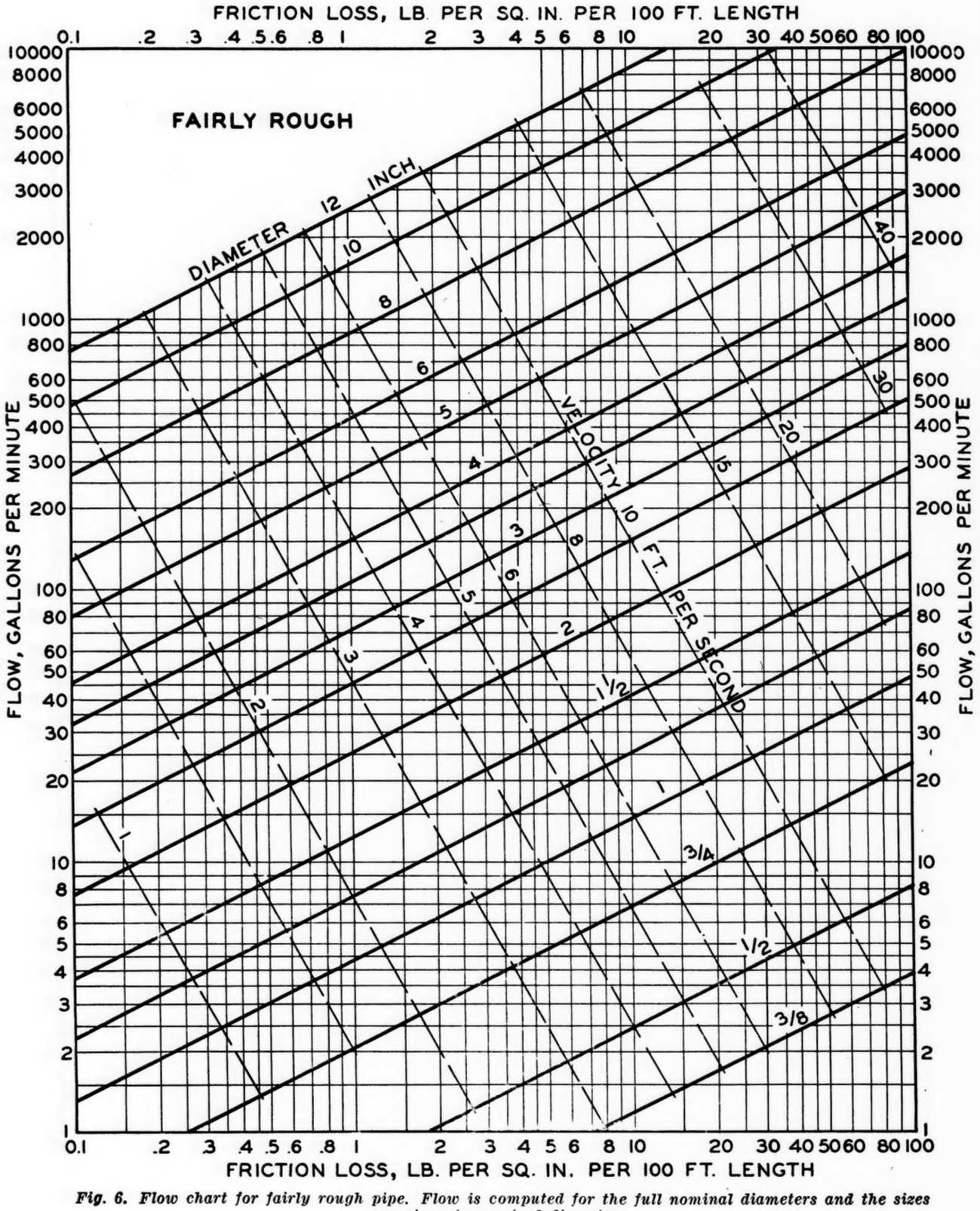


Fig. 6. Flow chart for fairly rough pipe. Flow is computed for the full nominal diameters and the sizes are given in nominal diameters.

Step 4. Water pressure, given, is 45 lb per sq in.

Step 5. Static head is .434 × 30 ft (given) or 13 lb per sq in.

Step 6. Refer to Fig. 3. Since the total flow is 475 gal, this calls for a 6-in. meter. The curve shows the pressure loss for this meter and the flow to be 5.5 lb per sq in.

Step 7. For flush valves, minimum pressure is 15 lb per sq in.

Step 8. Adding results from Steps 5, 6 and 7:

$$13 + 5.5 + 15 = 33.5 \text{ lb per sq in.}$$

Step 9. Subtracting this from the service pressure, Step 4, we have 85 — 33.5 = 51.5 lb per sq in. available for piping loss.

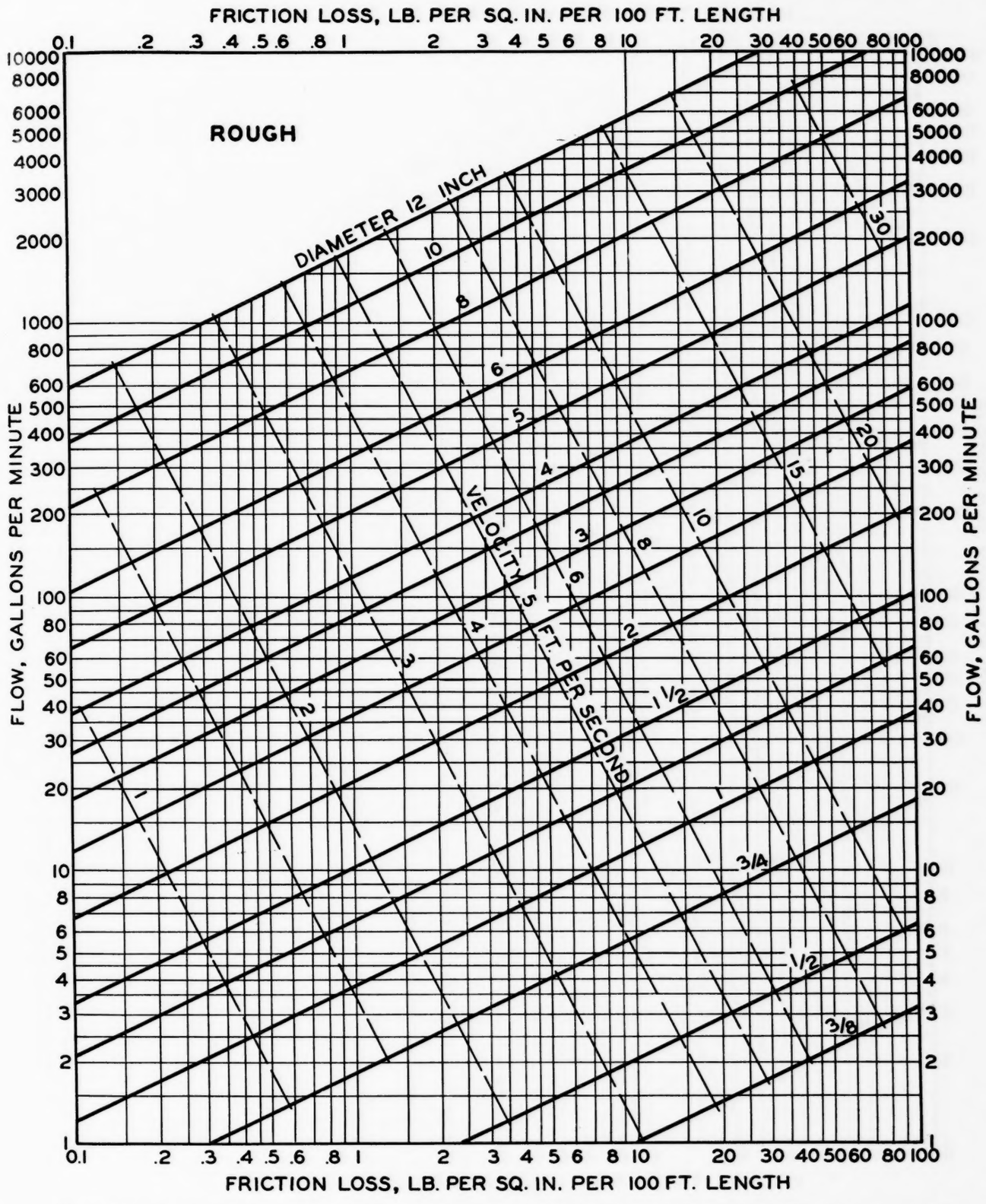


Fig. 7. Flow chart for rough pipe. Flow is computed for the full nominal diameters and the size designations are given in nominal diameters.

Step 10. Length of pipe, 840 ft, given.

Step 11. Equivalent length of fittings, 395 ft, given.

Step 12. Total equivalent length (Step 10 + Step 11) is 840 + 395 = 1235 ft.

Step 13. Divide available pressure from Step 9 by total equivalent length from Step 12 (or 51.5 ÷ 1235) and multiply by 100, giving 5.14 lb per sq in. per 100 ft friction loss.

Step 14. For steel pipe with highly caking water use Fig. 7. Above 5.14 and opposite 475 (from Step 3) find that a 5-in. main is required to the first branch. The velocity is found to be 8 fps.

Number of Degree-Days for December, 1941

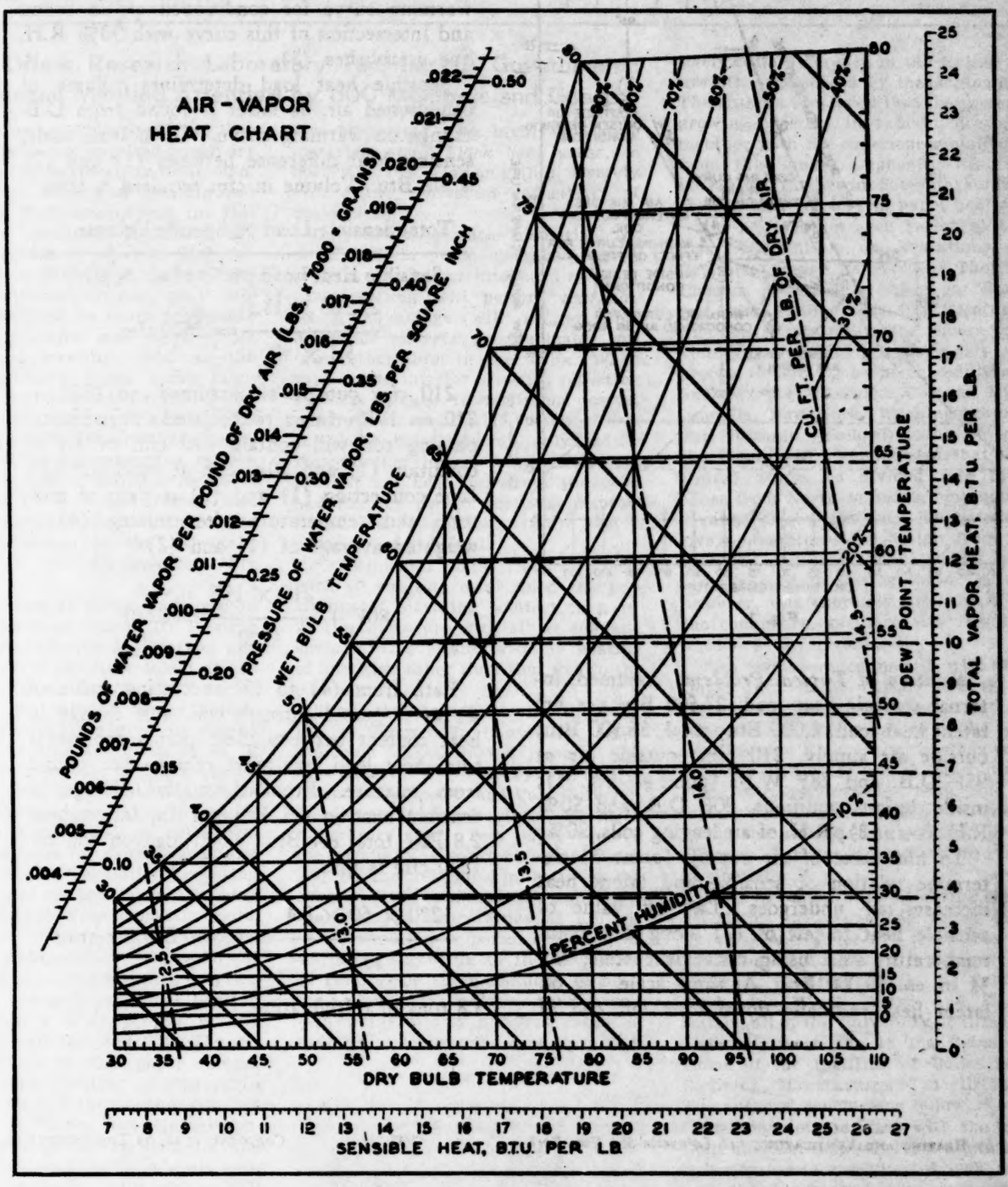
HEATING AND VENTILATING continues its fourteenth year of publishing degree-day data for various large cities.

City	Degree-Days Dec. 1940	Degree-Days Dec. 1941	Degree-Days Season 1941-42
Albany, N. Y.	1127	1097	2343
Alpena, Mich.	1161	1081	2527
Atlanta, Ga.	534	531	948
Atlantic City, N. J.	725	741	1356
Baker, Ore.	984	1032	2790
Baltimore, Md.	685	698	1233
Binghamton, N. Y.	1025	998	2099
Birmingham, Ala.	445	472	851
Bismarck, N. D.	1334	1280	3136
Boise, Idaho	921	930	2275
Boston, Mass.	953	923	1822
Buffalo, N. Y.	996	966	2061
Burlington, Vt.	1284	1214	2747
Cairo, Ill.	671	686	1300
Canton, N. Y.	1341	1276	2826
Charles City, Iowa	1254	1098	2431
Charlotte, N. C.	556	556	975
Chattanooga, Tenn.	645	649	1234
Cheyenne, Wyo.	1039	1089	2830
Chicago, Ill.	977	889	1859
Cincinnati, Ohio	779	794	1549
Cleveland, Ohio	877	826	1784
Columbia, Mo.	837	788	1594
Columbus, Ohio	810	833	1667
Concord, N. H.	1178	1137	2623
Concordia, Kan.	992	897	1878
Davenport, Iowa	1010	928	1918
Dayton, Ohio	845	826	1690
Denver, Colo.	915	932	2179
Des Moines, Iowa	1077	986	2043
Detroit, Mich.	1021	912	1963
Dodge City, Kan.	839	856	1768
Dubuque, Iowa	1105	1011	2097
Duluth, Minn.	1431	1319	3169
Eastport, Me.	1186	1138	2735
Elkins, W. Va.	755	832	1872
El Paso, Tex.	452	524	945
Erie, Pa.	910	866	1809
Escanaba, Mich.	1263	1127	2692
Evansville, Ind.	750	779	1550
Fort Smith, Ark.	589	603	1120
Fort Wayne, Ind.	957	947	2032
Fort Worth, Tex.	495	464	852
Grand Rapids, Mich.	1027	909	1989
Green Bay, Wis.	1261	1083	2404
Greensboro, N. C.	656	666	1283
Harrisburg, Pa.	853	852	1675
Hartford, Conn.	1006	986	2029
Helena, Mont.	1125	1256	3276
Huron, S. D.	1256	1153	2651
Indianapolis, Ind.	847	822	1617
Ithaca, N. Y.	1008	1008	2158
Kansas City, Mo.	859	778	1564
Keokuk, Iowa	920	844	1720
Kewanee, Ill.	970	913	1865
Knoxville, Tenn.	583	610	1198
La Crosse, Wis.	1231	1091	2353
Lander, Wyo.	1273	1232	3212
Lansing, Mich.	1081	950	2158
Lewiston, Maine	1289	...	...
Lincoln, Neb.	1050	967	2036
Little Rock, Ark.	518	596	1089
Los Angeles, Calif.	156	254	403
Louisville, Ky.	701	713	1371
Lynchburg, Va.	650	647	1224
Madison, Wis.	1205	1071	2284
Marquette, Mich.	1232	1120	2740
Memphis, Tenn.	514	615	1178
Milwaukee, Wis.	1099	1011	2255
Minneapolis, Minn.	1335	1203	2634
Nantucket, Mass.	818	839	1722
Nashville, Tenn.	584	608	1174
New Haven, Conn.	912	898	1760
New Orleans, La.	186	211	389
New York, N. Y.	810	834	1532
Norfolk, Va.	521	547	890
Northfield, Vt.	1341	1276	2975
North Platte, Neb.	1053	1054	2311
Oklahoma City, Okla.	682	643	1244
Omaha, Neb.	1068	995	2128
Oswego, N. Y.	1066	1050	2230
Parkersburg, W. Va.	708	771	1571
Peoria, Ill.	962	886	1845
Philadelphia, Pa.	764	779	1392
Pittsburgh, Pa.	762	796	1622
Pocatello, Idaho	1056	1091	2893
Portland, Me.	1263	1103	2591
Portland, Ore.	650	658	1512
Providence, R. I.	916	945	1870
Pueblo, Colo.	1000	1007	2239
Raleigh, N. C.	553	583	988
Reading, Pa.	833	842	1612
Reno, Nev.	842	861	2173
Richmond, Va.	640	657	1177
Rochester, N. Y.	1061	1029	2204
Roseburg, Ore.	661	649	1559
St. Joseph, Mo.	936	840	1743
St. Louis, Mo.	780	735	1440
Salt Lake City, Utah	937	889	2171
Sandusky, Ohio	936	855	1790
San Francisco, Calif.	292	360	789
Sault Ste. Marie, Mich.	1281	1277	3090
Scranton, Pa.	970	951	1967
Seattle, Wash.	574	651	1632
Spokane, Wash.	967	971	2542
Springfield, Ill.	885	816	1655
Springfield, Mo.	791	798	1616
Syracuse, N. Y.	1075	1053	2234
Tacoma, Wash.	630	706	1796
Terre Haute, Ind.	842	805	1589
Toledo, Ohio	964	890	1892
Trenton, N. J.	821	841	1589
Utica, N. Y.	1123	1082	2360
Washington, D. C.	682	715	1306
Wichita, Kan.	852	783	1631
Yakima, Wash.	952	915	2178

Figures in this table, with three exceptions, are calculated by HEATING AND VENTILATING from local weather bureau reports. Exceptions are Utica, Lewiston, and Kewanee, figures for which are furnished through the courtesy of R. C. Edmunds, Manager of Coke Sales, Central New York Power Corp., Utica, N. Y.; Norman E. Ross, Bursar, Bates College, Lewiston, Me.; and J. M. Hartman, Engineering Department, Kewanee Boiler Corp., Kewanee, Ill., respectively. HEATING AND VENTILATING will welcome an opportunity to make arrangements with readers who are keeping degree-day records over a period for important communities not listed above in order to make such data available to the industry.

GEAUQUE AIR CONDITIONING CHART

The air-vapor chart below, designed by R. E. Geauque, is based directly on heat content in air in Btu per pound of dry air and makes possible direct reading of total heat content of moist air. This is a feature of the chart. Explanation of chart's use appears on reverse side this sheet.


AIR-VAPOR
HEAT CHART
POUNDS OF WATER VAPOR PER POUND OF DRY AIR (LBS. x 7000 = GRAINS)
PRESSURE OF WATER VAPOR, LBS. PER SQUARE INCH
WET BULB TEMPERATURE
CU. FT. PER LB. OF DRY AIR
DEW POINT TEMPERATURE
TOTAL VAPOR HEAT, B.T.U. PER LB.
PERCENT HUMIDITY
DRY BULB TEMPERATURE
SENSIBLE HEAT, B.T.U. PER LB.

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H. & V.'s REFERENCE DATA—215

GEAUQUE AIR CONDITIONING CHART

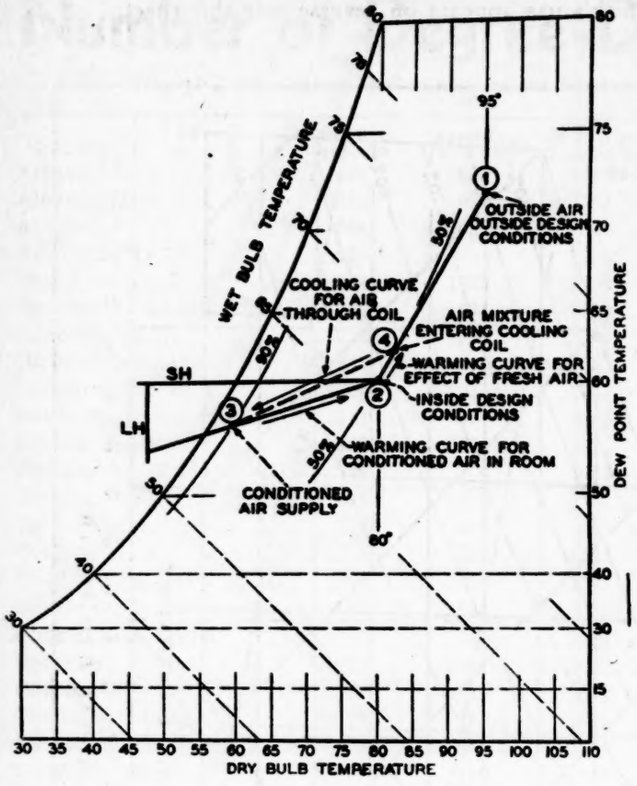
WET BULB TEMPERATURE
DEW POINT TEMPERATURE
DRY BULB TEMPERATURE
OUTSIDE AIR OUTSIDE DESIGN CONDITIONS
COOLING CURVE FOR AIR THROUGH COIL
AIR MIXTURE ENTERING COOLING COIL
WARMING CURVE FOR EFFECT OF FRESH AIR
INSIDE DESIGN CONDITIONS
WARMING CURVE FOR CONDITIONED AIR IN ROOM
CONDITIONED AIR SUPPLY
SH
LH
30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110

Fig. 1

Solution of Typical Problem. Assumed, internal sensible heat load, 27,500 Btu per hr; latent heat load, 8,000 Btu; total, 35,500 Btu; outside air supply, 210 cfm; outside air at 95F D.B. and 78F W.B. (point 1, Fig. 1); inside design conditions, 80F D.B. and 50% R.H. (point 2); R.H. of air leaving coils, 90%.

To find state of air supply (point 3) determine relation of sensible and latent heat increases air undergoes. Lay off value of sensible heat to left of (2) along dew point temperature line, using convenient scale, say ¼ in. = 10,000 Btu. At same scale, lay off latent heat vertically down from left end of sensible heat line just drawn. Line from the bottom of latent heat line to point (2) is warming curve for conditioned air in room, and intersection of this curve with 90% R.H. line establishes (3).

Sensible heat load determines volume of conditioned air, as latter is found from D.B. change on warming curve. On bottom scale, sensible heat difference between (3) and (2) is 5.1 Btu. Volume in cfm required is then

$$\frac{\text{Total Sensible Load} \times \text{Specific Volume}}{\text{Sensible Heat Load per lb of air} \times 60} =$$

$$\frac{27{,}500 \times 13.5}{5.1 \times 60} = 1220 \text{ cfm.}$$

210 cfm outside air assumed, so 1220 — 210 = 1010 cfm is recirculated. Air mixture passing coil will contain 210 cfm of air at condition (1) and 1010 cfm at condition (2). Line connecting (1) and (2) is path of mixture, and temperature after mixing (4) is weighted average of (1) and (2):

$$80\text{F} + \frac{210 \times 15\text{F}}{1220} = 82.6\text{F}$$

Path from (4) to (3) is cooling curve of air as it passes through coil, and change in heat content between these points represents total heat load coil must remove per pound from mixture. From chart this change in sensible heat is 5.6 Btu per lb, latent heat 2.8 Btu, total 8.4 Btu. Total load on coil for 1220 cfm is thus

$$\frac{1220 \times 60 \times 8.4}{13.5} = 45{,}600 \text{ Btu per hr or}$$

3.8 tons of refrigeration.

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NEWS OF THE MONTH

ASHVE Offers Research Laboratory Facilities to Government; 48th Annual Meeting Attended by 600 Members and Guests

PHILADELPHIA — Believing that the national emergency required an all-out effort from the engineering profession, the American Society of Heating and Ventilating Engineers offered the full use of its facilities, including the trained personnel of its Research Laboratory at Pittsburgh, to the Government without expense, and subscribed $40,000 of its funds to defense bonds. This action was taken at its 48th annual meeting, held at the Bellevue-Stratford Hotel here, January 26-28, which attracted nearly six hundred members and guests, the largest registration recorded at a meeting without an accompanying exposition. With over a hundred members already in U. S. armed forces, and many in the allied armies, there was definite indication of the important work which ASHVE members are doing.

The final session was a joint session with the National Warm Air Heating and Air Conditioning Association, and the capacity of the Rose Room at the hotel was taxed, due to the interest shown in the subjects under discussion. A stimulating address on Smoke Control for Cities was given by R. R. Tucker, Commissioner of Smoke Regulation for the City of St. Louis. He outlined the measures taken to remove the causes of the smoke nuisance, educational program for public benefit and pointed out that regulations covering hand-fired and mechanical fuel burning equipment applied to domestic users, as well as industry and railroads.

Prof. F. W. Hutchinson, University of California, presented the first progress report of research on panel heating and cooling, a joint project of the University and the ASHVE. The report appeared in the paper "Panel Heating and Cooling Performance Studies" under the authorship of Profs. B. F. Raber and Hutchinson. They gave experimental data for the feeling of warmth on 50 subjects in a reflecting enclosure with air at 60F and surfaces at 57F and with no heating other than that due to the occupants. The authors' conclusions follow:

Inside surfaces of low emissivity (high reflectivity) can be effectively used to reduce the heating requirements of an occupied room. This reduction is independent of the type of heating system.

Effectiveness of reflective walls varies inversely with room size and decreases rapidly with a reduction in the reflectivity of the surface. The equivalent reflectivity of a room may be low even though a large part of the inside surface is covered with highly reflective material; small *black body* areas, as open windows, door or grilles, severely reduce the equivalent reflectivity of the enclosure.

If polished surface insulation, as metal foil, is to be used in a given structure, and if architectural or other considerations will permit, an additional advantage will accrue from using the material on the inside surface rather than in the walls. When used in the interior of walls, reflecting surfaces reduce transmission losses; when used as an inside surface finish, the same materials not only reduce transmission losses, but act also to prevent net heat loss from the body and thereby permit realizing comfort with a lower air temperature and a reduced heating load.

Experimental data from 50 tests with 50 subjects established the possibility of attaining comfort in a reflecting enclosure with air at 60F and surfaces at 57F and with no heating of any kind other than that due to the occupants.

"Radiation as a Factor in the Feeling of Warmth in Convection, Radiator and Panel Heated Rooms" was the title of a paper by Dr. F. C. Houghten, director, and Carl Gutberlet and E. C. Hach, all of the Research Laboratory staff. This paper covered the results of a previous study which showed the relationship between the effect of mean radiant temperature and the effective temperature of the air in determining a person's feeling of warmth. According to the discussion of results the three methods of heating—convectors, radiators, and panels —involving widely different ratios of radiated and convected heat, gave relatively little difference in the feeling of warmth experienced by the occupants. The authors concluded that the present growing interest in radiant heating, together with the experiences obtained from this study, emphasize the importance of further fundamental studies of such basic factors in panel heating.

E. D. Eastwood (left), Seattle, new president, with E. K. Campbell, Kansas City, new treasurer of the ASHVE.

The ASHVE Research Technical Advisory Committee on Sensations of Comfort, through its chairman Thomas Chester, presented a report on "Comfort with Summer Air Conditioning." The report referred to the papers previously presented to the Society on proper indoor atmospheric conditions and covering Pittsburgh, Toronto, Minneapolis, New York, Washington and San Antonio. Following the review the Committee recommended that the United States be divided into four zones from North to South, embracing a range of recommended indoor effective temperatures for design from 70 to 73F. Any idea that finality has been reached in setting these figures, however, was expressly disclaimed by the committee, as there still remains a wide field for research.

Two engineers connected with McQuay, Inc., R. W. Evans and C. J. Otterholm, presented a paper on the "Use of Cold Accumulators in the Air Conditioning Field" in which they covered the characteristics of the cold accumulator, performance tests, and a logical and detailed method of calculating the cooling load, followed by a selection chart for picking the required accumulator.

Tests to compare the operating characteristics of a one-pipe forced hot water system under two conditions of operation were reported in a paper by Profs. A. P. Kratz and M. K. Fahnestock, and W. S. Harris and R. J. Martin, all of the University of Illinois. The tests were run in the Research Home of the Institute of Boiler and Radiator Manufacturers at Urbana. The authors' conclusions follow:

Operation of the plant with the low limit aquastat maintaining a minimum boiler water temperature of 165F and with the flow control valve preventing circulation of water during the off-periods of the circulator resulted in an increase in the seasonal operating cost of approximately 11.7% as compared with operation with the low limit aquastat eliminated and the flow control valve locked open. The increase in fuel consumption was caused by increased heat losses from the top of the chimney accompanying the higher average boiler water temperature maintained in mild weather with the flow control valve effective.

No over runs in the temperature of the air in the rooms were experienced

with either method of operation. The maximum variation in air temperature at the 30-in. level in any room did not exceed 1F.

In severe weather the average difference between the temperature of the air 3 in. below the ceiling and that 3 in. above the floor was about 4.5F. The method of operating the heating system had no material effect upon this temperature difference.

The temperature of the inside surfaces of the exposed walls in severe weather was only about 2.8F lower than that of the air in the rooms.

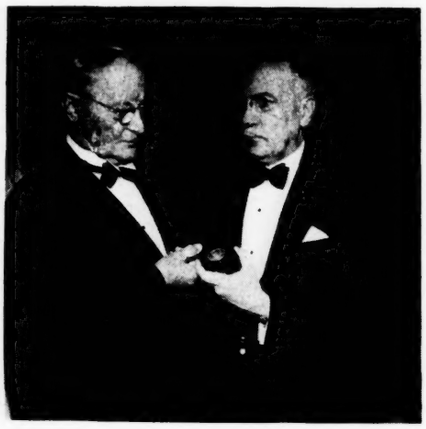
The application of one inch of rigid insulation to a radiator recess lined with reflective insulation, backed by wood sheathing, one inch air space and 4-in. brick veneer resulted in a reduction of approximately 45% in the heat loss as compared with that lost through the same recess without insulation.

Ratios of the friction-heads in welded and screwed elbows were given for three velocities and three pipe sizes in a paper entitled "A Comparative Study of Friction-Heads in Screwed and Welded Elbows" by Dr. Giesecke and Prof. J. S. Hopper of A. and M. College of Texas, the result of research sponsored by the ASHVE and the college. As one of their conclusions the authors reported that until additional experimental data are secured it may be well to base friction-head calculations on the friction-heads in screwed elbows, and to reduce the results to one-half, or slightly less, for welded elbows of corresponding sizes.

The development of direct-fired unit heaters for gas and oil fuel was reviewed and test data were given for units of 1,000,000 Btu capacity in a paper on "Design and Performance of a Direct-Fired Unit Heater" by R. M. Rush and H. A. Pietsch, Dravo Corp. In addition to temperature readings in an industrial building heated by this type of unit, the authors included application data, together with some information on the relation of these units to the defense program.

A report on the cooperative research project by the ASHVE and Case School of Applied Science was presented in a paper entitled "Entrainment and Jet-Pump Action of Air Streams" by Prof. G. L. Tuve, and G. B. Priester, and D. K. Wright, Jr., all of Case. This paper included an examination of data and results by several investigators together with a report on experimental work at Case on the behavior of an air stream introduced into a space by a jet device. As the authors pointed out, this subject is of interest in connection with such applications as fume exhausters, gas and oil burners and steam ejector refrigeration as well as from the standpoint of air diffusers.

Although tests were limited to air outlets less than 160 sq in. in area,



Dr. F. E. Giesecke (left) receives the F. Paul Anderson medal from Thornton Lewis at the ASHVE banquet.

with outlet velocities up to 2400 fpm, a variety of types and sizes were tested, yielding the following conclusions:

The total momentum of a free air stream remains practically constant throughout its measurable length.

Entrainment of room air is continuous throughout the length of an air stream, and amounts to 20 to 70% of the primary air volume per foot of travel or throw. This percentage entrainment may be increased greatly by using slot-type outlets or wide-angle spreading grilles.

The ratio of entrained air to primary air *at a given distance* from the outlet face varies as follows:

(a) Entrainment ratio decreases as the area of the outlet is increased.
(b) Entrainment ratio is practically independent of the outlet face velocity.
(c) Entrainment ratio is practically the same for all square and rectangular outlets of the same area, except the very narrow slots.

Total throw or blow of an air stream is directly proportional to the outlet velocity.

The air stream from a narrow-slot outlet becomes almost circular toward the end of its throw.

The maximum velocity at any plane at right angles to the stream is usually about three times the average velocity in that plane.

The *average* jet angle for the stream from a rectangular outlet of any shape, without spreading vanes, is about 19 deg, ±5 deg depending on type of approach, type of outlet and velocity.

Air entrainment by a venturi-mixer unit is small compared with the natural entrainment by a free air stream.

For increasing the air mixing and reducing the throw, the advantages of the narrow slot or of the narrow-ring ceiling outlet are clearly indicated, as are those of the wide-spreading grille.

Prof. D. W. Nelson, D. H. Lamb and G. E. Smedberg presented a paper on "The Performance of Stack Heads Equipped with Grilles," the result of research sponsored by the ASHVE and the University of Wisconsin. The conclusions were:

More uniform flow was found over the face of the stack head with the use of grilles having high resistance than with those having low resistance. Low negative flow area is associated with low face areas of plain stack heads or with the use of high resistance grilles. Reduction of negative flow area results in higher face velocities and reduction of negative flow area by use of high resistance grilles is more pronounced with high face heights.

The angle of discharge from stack heads with various grilles is not influenced appreciably by the velocity in the stack, but is affected by the type of stack head and grille. In general, the angle of discharge is lower with decreased stack head face height and with smaller free area of the grille. With low free areas of grilles negative angles of discharge were obtained. Pressed grilles gave angles of discharge below the horizontal, whereas grilles with horizontal bars resulted in discharge more nearly horizontal.

With decrease in net face area, the static pressure increases slowly at first while the negative flow area is decreasing to zero; with further decrease of free area the static pressure at the base of stack head goes up rapidly. Pressed grilles had the lowest free areas which together with low coefficients of discharge, resulted in the highest static pressures in all cases.

The second progress report of research sponsored by the ASHVE in cooperation with the Towne Scientific School of the University of Pennsylvania, and entitled "Vapor Pressure of Ice from 32 to —280F," was presented by Dean John A. Goff of Towne Scientific School. Based on the latest available data Dean Goff has included vapor pressures for ice to exceedingly low temperatures in tables presented in his paper.

Dr. C.-E. A. Winslow, chairman of the Technical Advisory Committee on Physiological Reactions, presented the report of his Committee in a paper entitled "Physiological Influence of Atmospheric Humidity." The paper was in three parts covering the influence of atmospheric humidity (1) in cool air upon body heat losses; (2) in warm air on body heat losses, and (3) on the dryness of nose and throat membranes. In regard to the last point the authors pointed out that investigations have shown that the drying effect on the mucous membrane is related to the absolute and not the relative humidity of the atmosphere.

(Report concluded on page 80)

THE DANGER LIES AT THE TURNS

Accidents lurk when power and speed crowd *PIPING TURNS* too!

In 6-day bicycle races, if riders come to grief—it's usually on the turns where speed and strain increase the danger. (I.N.S. photo)

Weld piping with TUBE-TURN fittings to prevent trouble at the crucial spots!

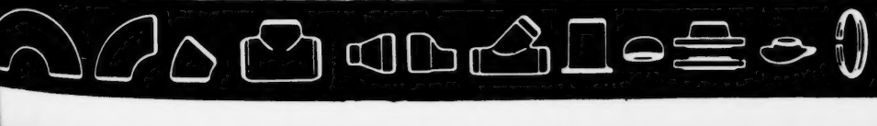
It takes strength and stamina to withstand the grueling pressure of a 6-day bike race, but that's nothing to the strain and stress imposed on many piping lines. The greatest concentration of pressure in pipe lines is placed in the turns—*wherever there is a change of flow direction.* Tube-Turn fittings are engineered for added protection *where the danger lies*—wherever elbows, returns, tees, reducers, laterals, nipples and flanges are used. You will find a type, size and weight of Tube-Turn fitting for *every* pipe welding need. Look for the Tube-Turn insignia welded on each fitting.

Write for Tube-Turn engineering data book and catalog.

TUBE-TURNS
INCORPORATED
LOUISVILLE, KY.

Branch offices: New York, Philadelphia, Chicago, Pittsburgh, Cleveland, Tulsa, Los Angeles. *Distributors everywhere.*

TUBE-TURN *Welding Fittings*
TRADE-MARK



HOW TUBE-TURN FITTINGS PROTECT WHERE FLOW DIRECTIONS CHANGE

This compact piping installation illustrates four common points that occasion *changes in flow direction*—a welding tee at the top, then a 90° elbow, a reducing outlet welding tee at the right, and a concentric reducer near the bottom. Tube-Turn welding fittings are used here to guard against danger at these turns.

News of the Month

Millions for Demountable Houses

WASHINGTON—Simplifying and speeding up the construction of war housing, the Federal Works Agency on January 9 launched a program for immediate erection of 42,000 demountable houses, with two-shift operation and a seven-day working week. Standard designs, simple construction and mass purchasing of equipment will be initiated to save months of construction time and to cut costs.

Straight-line responsibility to the Federal Works Administrator will be the other dominant feature of the new operation. The entire demountable-house program, involving an estimated outlay of $153,000,000, will be carried out by a group of FWA housing specialists headed by Rufe B. Newman, Jr. Mr. Newman has been Chief of Construction of the Defense Housing Division of the FWA, in charge of the erection of all demountable houses that have been built to date under the FWA defense housing construction programs that were financed with Lanham Act and other funds.

The cooperation of local housing authorities will be sought in carrying out the new demountable-house program and local engineers and local architects will be employed wherever feasible. Efforts will be made to find sites where utility services already are in place. If a desirable site is found which is without utilities installations, FWA will build the facilities as well as the houses—a new short cut time-saving practice.

Streamlining both the demountable and permanent defense housing construction programs, FWA has appointed a committee for the selection of standardized house plans. This committee consists of A. C. Shire, O. Kline Fulmer, and G. S. Underwood, all associated with FWA agencies.

A.C. for Propeller Laboratory

HARTFORD, CONN.—Constantly expanding its facilities both for manufacture and research, the Hamilton Standard Propeller Division of United Aircraft has completed a new fully-equipped propeller laboratory, with an area of 6,000 square feet. It includes, besides a "cold room," for testing propellers at low temperatures, a "whirl rig" by means of which the effects of high temperatures, excess rotational speeds and of erosion on propellers may be studied.

At the rear of the whirl rig chamber is a radiator heated by exhaust gases of the engine that drives the propeller shaft set in the room. This radiator can heat the air in the chamber to 150F. With the cold room and the whirl rig the new laboratory provides means for studying propeller operations over a temperature range of 200F—from —50F to 150F.

A.C. Council Elects Voisinet

Walter E. Voisinet

BUFFALO—Walter E. Voisinet, president of Air Conditioning Accessories, was elected president of the Air Conditioning Council of Western New York at the annual election. Other officers elected are:

Vice-president, Sherman W. Strouse, Buffalo representative of The Trane Co.; treasurer, Harry C. Schafer, Iroquois Gas Corporation. Walter P. Davis of the Buffalo Niagara Electric Corporation was re-appointed executive secretary for his sixth term.

The following directors were elected for two-year terms: DeWitt L. King, Niagara Blower Company; W. A. Meiter, Worthington Pump & Machinery Corporation; K. N. Nichols, Westinghouse Electric & Manufacturing Company; H. Schmidt, Fedders Manufacturing Company; W. J. Williamson, Cataract Ice Company of Niagara Falls, and Mr. Strouse.

Secretary Davis announced that the Council will conduct an educational program during 1942 designed to bring to plant engineers, especially in defense industries, information on the operation and maintenance of control instruments in air conditioning. A booklet will be prepared by the Council on this subject.

Mr. Davis said the Council also is offering its services to the Buffalo Defense Council.

Appoints Defense Committee

BUFFALO—How the Oil Heat Association of Western New York can serve in civilian defense was discussed at a meeting of the association's board of directors January 15. Joseph Collins, newly elected president, named a committee on civilian defense, consisting of Ed Zudeck, chairman; George Sloan, Fred Kirschhofer and William Maunz. It was suggested that the association members act as an emergency group for oil burners during blackouts.

NAFM Has 25th Anniversary

DETROIT—Organized in February, 1917, the National Association of Fan Manufacturers will celebrate its 25th anniversary at its annual meeting to be held here, February 12. Started primarily as a credit association, the scope of the activities has been gradually enlarged during the intervening years to include research, engineering standards, educational work in the proper uses of air moving machinery, improved working conditions and other allied subjects.

Mass Buying for Defense Homes

WASHINGTON — Heating equipment and nearly all other types of equipment required for defense housing projects built under Federal Works Agency supervision will be bought in the future through the Procurement Division of the United States Treasury on a mass purchasing basis in order to expedite delivery and distribution, and for purposes of economy, it was announced January 11 by Assistant Federal Works Administrator Baird Snyder III, acting for Administrator Philip B. Fleming.

On the basis of expenditures for equipment in earlier defense housing programs, the mass purchasing procedure promises to save several million dollars in the cost of equipment, needed for a proposed defense housing program of 120,000 dwelling units, Mr. Snyder said.

L.A. Surveys Cooling Plants

LOS ANGELES — The Heating and Ventilating Division of the Los Angeles Department of Building and Safety, which has supervision over refrigeration plants, is making a survey of all refrigeration systems in the city of more than 100 tons ammonia and sulphur capacity to check on violations of the safety device provisions of the municipal code.

Approximately 200 installations are embraced in the survey. The city ordinance provides that all ammonia and sulphur refrigeration plants of more than 100 tons capacity be equipped with automatic high-pressure controls to take care of the system in case of water shortage, and also provides that means be available for discharge of the refrigerant into the sewer.

Oil Heat Group Elects Walsh

BOSTON—At the annual meeting of the Massachusetts Oil Heating Association, January 13, the following officers were elected for 1942: president, J. F. Walsh; vice-president, R. E. Eldridge; secretary-treasurer, Fred N. Beckwith; directors, J. L. Gamble, Boston; C. E. Gurney, Leominster; F. W. Heaney, Watertown; W. A. Hickey, Wakefield; J. A. Ivester, Arlington; C. B. Leacy, Newton; F. P. Scully, Cambridge.

Equitable Enters Housing Field

NEW YORK—The Equitable Life Assurance Society of the United States will build a large scale garden-type housing project to accommodate 1,200 defense workers and their families in Brooklyn, not far from the Navy Yard.

Starrett Brothers & Eken, Inc., will be in charge of construction, which will begin shortly.

Salvaging Steel Dust

★ ★ for ★ ★

Needed Scrap Supply

BETH-CU-LOY GALVANIZED STEEL SHEETS

Here's a good example of a type of work by a sheet-metal contractor which will mean much to America's war effort: a dust-collecting system to service a battery of steel-billet grinders. The entire unit is shown as preassembled in the contractor's shop, before being knocked down for delivery to point of installation.

In action, the system will handle a highly abrasive mixture of fine steel dust and sharp carbide particles resulting from grinding of steel billets. The unit will not only "clear the air" for the operators, making for better, faster work, but also salvage both the steel and the carbide for future use.

When you figure on such industrial work, where corrosion and abrasion are both heavy factors, remember to specify Beth-Cu-Loy as this contractor did. Doubly guarded by a tight coat of zinc plus 0.20 to 0.30 per cent copper in the steel itself, Beth-Cu-Loy Sheets will stand up longer in the most severe conditions, yet the added cost is negligible—only a few cents more per sheet.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY

Rogers Speaks on New Aspects of Insulation to Boston Group; Discusses Heat Barriers in Defense Homes and Factories

CAMBRIDGE, MASS.—There was an excellent attendance at the January meeting of the Massachusetts chapter, ASHVE, January 20, when Tyler Stewart Rogers, an architectural insulation authority spoke on "New Aspects of Insulation." Mr. Rogers handled his subject in three phases: small homes; conservation of national resources (such as fuel, transportation and man power) through insulation; and industrial applications of insulation.

Floor temperatures will be important considerations in low cost defense housing, he said, especially where the dwellings are without basements or cellars. Such structures must be studied with respect to heat losses through the walls and floors. Heat transmission through the walls is the only thing to be controlled. Insulation is important in these small homes, in terms of human comfort, as well as of fuel savings. We have a ten per cent yardstick of temperature margins or differentials between wall surfaces and the middle of the room, but we need a better one than this, and it is something to which engineers might apply some study. Minimum inside wall surface temperature should be 60F and the top 68 to 70F. The comfort range in homes can be achieved with a comparatively small amount of any type of insulation, and insulation is needed in small homes, particularly the defense housing types.

Government agencies are considering insulation in defense housing and industrial buildings of all types, and are finding that they can save millions—in fuel costs, man hours saved, human efficiency and other ways.

A mandatory provision will soon be included in all plans for defense housing, he said, limiting the metal to be used in heating to 350 pounds total, the total heat loss to 80,000 Btu per dwelling and 66 Btu per square foot of floor area. It would then be up to the builder or architect to keep the house within these mandatory limits. But, said Mr. Rogers, in very few areas of the country would these requirements be found stringent. There are no requirements as to method of heat distribution.

This provision might possibly add fifty cents to a dollar a month to the cost of the house to the buyer or renter, but conservation of materials and the savings in fuel would more than offset this and actually raise the standard of living instead of lowering it.

Turning next to industrial applications and giving some facts particularly about United States built bomber plants, he cited one case of an industrial concern that by insulation effected a fuel saving of 53% at an original cost of $7000 for the insulation. The saving amounts to $2400 a year, so that in three years the cost of insulation is amortized and the concern continues with its annual fuel cost saving indefinitely.

Telling of two bomber plants in the southwest, built under supervision of army engineers and engineered by The Austin Company, in consulation with insulating engineers, he estimated that the insulation, unique in its design, will save the government or operators of the plant $100,000 a year, through the roof and wall insulation, which not only cuts down heat loss and heat gain, but saves on the refrigeration in the air conditioning system, also helping to make the structure sound proof.

Stokers Help Pittsburgh Air

PITTSBURGH, PA.—Despite difficulties imposed by priorities and other wartime conditions, Pittsburgh's new Bureau of Smoke Prevention has made considerable progress in its attempt to reduce the smoke nuisance, a report reveals.

Concrete evidence of progress is shown by a list of seventy-five large buildings and industrial establishments which have made smoke-reducing improvements in their furnace apparatus or firing methods since October 1, when the bureau was created.

Thirty-two of the establishments achieved "clear stacks" by installing stokers and, in a few cases, new boilers.

Twenty-five improved firing methods or made adjustments in stoker operation.

Seven made other improvements, such as introducing secondary air over their fires or overhauling stokers.

1941 FHA Houses Total 215,000

WASHINGTON — Federal Housing Administration transacted a record volume of business during 1941, Administrator Abner H. Ferguson announced January 17. New peaks were reached in the number of homes started under the FHA program, as well as in the volume of applications for mortgage insurance and the volume of insurance approved.

More than 215,000 dwelling units were started under FHA inspection during the year, compared with 185,000 in 1940. Most of this construction consisted of single-family dwellings valued at less than $6,000 located in defense industrial areas.

Filters Discussed at Los Angeles

LOS ANGELES — A special National Defense committee, to cooperate with the Army, Navy and Home Defense commands in co-ordinating the facilities of the heating and ventilating industry of Southern California with the war effort, was appointed by the Southern California chapter of the ASHVE at its January meeting.

Appointed to the committee by President Arthur Hess were Frank McDonald of the Barber-Colman Co., chairman; Ben Badt, American Blower Co.; and Lloyd Petticolas, who is associated with O. T. Ott, consulting engineer.

Initial efforts are expected to take the form of supplying speakers to address various groups on how to handle emergency problems arising from the bombing of heating and cooling plants; and the supplying of technical data. The committee has also been empowered to offer the personnel of the chapter when needed in emergencies dealing with the speedy repair of broken ammonia, steam, water lines, etc.

Filters as Used in the Air Conditioning Industry were discussed during regular session of the meeting by three speakers. R. S. Farr, Farr Co., Los Angeles, spoke on Permanent Type Filters, and outlined the construction and operating features of cleanable cloth, dry cleanable, and oil-wet cleanable filters. He devoted the greater part of this time to discussing viscous coated filters. Mr. Farr declared that the field for oil-wet filters of the permanent type is constantly increasing. Joseph S. Earhart, Ross Heater Mfg. Co., discussed Automatic Type Filters — specifically, two types of automatic viscous filters, the single-curtain, two pass type, and the two-curtain, four pass type.

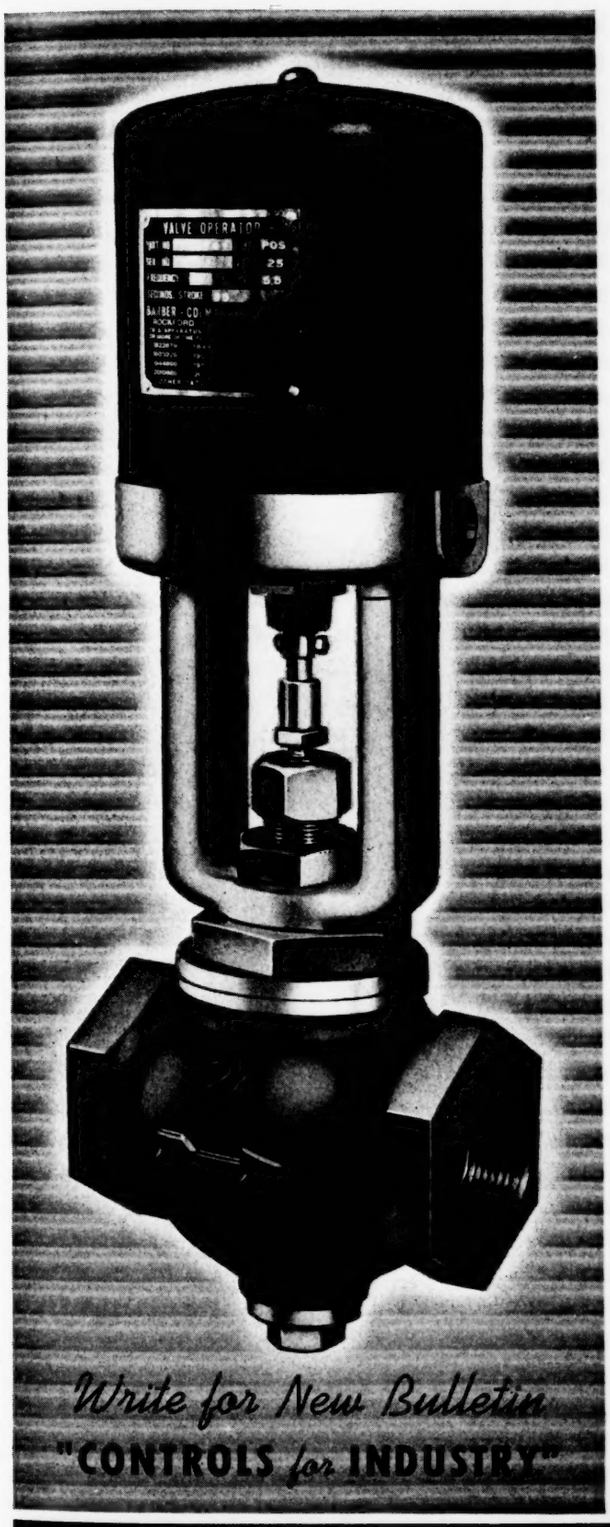
Electric Filters was discussed by Frank Parks of Western Air & Refrigeration, Inc.

Newark's Smoke Increases

NEWARK, N. J.—The quantity of smoke and soot over this city has increased sharply with the set-up in industrial production hereabouts. There was 50% more pollution in the air in 1941 than in 1940, William B. Schaum, head of the Newark Smoke Abatement Bureau, estimates. In a report to Safety Director Keenan he pointed out that bureau received 39% more complaints than it had in 1940.

Although, Mr. Schaum pointed out, the smoke nuisance can be eliminated by proper use of fuel burning equipment, the bureau anticipates a continued increase in smoke complaints as more industries in this area change over from peace-time to war production.

MOTOR-OPERATED VALVES FOR INDUSTRIAL SERVICE



MAXIMUM SERVICE
Controls
by
BARBER-COLMAN COMPANY
MINIMUM MAINTENANCE

CONTROL OBTAINABLE...

Valves can be furnished to provide Positive (2-position), Floating, or Proportioning control, governed by liquid level or float switches, pressure switches, density controlling switches, thermostats, relays, push-button controllers, pH controllers, recording temperature controllers, time cycle controllers, or any of a number of other standard control instruments.

FOR SERVICE ON...

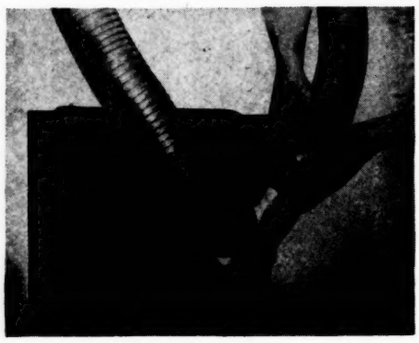
Valve bodies can be furnished with suitable motor-operators, in a wide range of sizes and types for service on high pressure or low pressure lines carrying steam, water, air, gas, dairy products, chemicals, food products, or numerous other industrial requirements.

FEATURES...

Barber-Colman Motor-Operated Valves operate from high voltage (115 v. AC) or low voltage (25 v. AC) control circuits, have either fixed-speed or variable-speed motors depending on the type of control required, and have completely oil-*submerged* motor units to permit continuous operation. In addition to these outstanding features, Barber-Colman Valves are built to high quality standards in every detail, to insure Maximum Service with Minimum Maintenance.

BARBER-COLMAN COMPANY 1224 ROCK STREET ROCKFORD, ILLINOIS

NEW EQUIPMENT

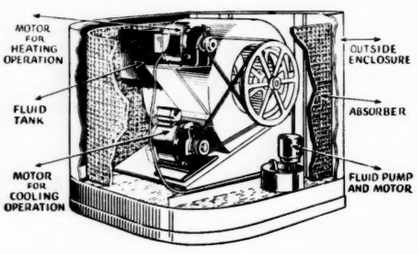


Dust Collector Flange

NAME—Two-way intake flange.
PURPOSE—To increase efficiency and to permit use of 3-in. hose so that the company's Dustkop dust collector can qualify under certain state codes specifying minimum hose size.
FEATURES—Intended for use with any of company's line of self-contained dust collectors, flange is installed on the intake side of unit directly over opening in cabinet. While sufficiently compact to conserve needed space, flange will admit ends of two pieces of 3 in. diameter flexible metal hose. Other end of the hose is connected with guards of grinding wheel or, in absence of conventional guard, sheet metal intake hood can be supplied.
METHOD OF OPERATION—Dust and dirt drawn from hood through hose and into intake flange passes through fan and through horizontally-placed filter. Filter stops dust, which falls back into removable pan, and cleaned air is returned to room, resulting in saving in heating costs.
MADE BY—*Aget-Detroit Manufacturing Co., 959 Book Bldg., Detroit, Mich.*

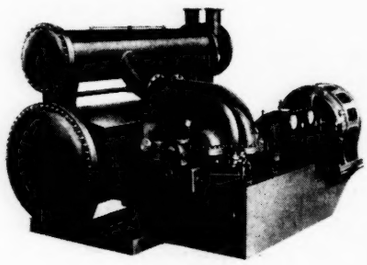
Evaporative Cooler

NAME—Rapids Custom-Aire.
PURPOSE — An evaporative cooling unit.
FEATURES—Unit includes dual motor driven fan, one motor being for heating operations, the other for cooling; fluid tank; absorber; fluid pump and motor, together with the necessary screen, recirculating and intake dampers and discharge grille.
MADE BY — *Rapids Products Company, Cedar Rapids, Iowa.*



Worthington Cooling Units

NAME — Worthington centrifugal refrigeration units.
PURPOSE — An extension of Worthington's new line of centrifugal water cooling systems now available to 1150 tons of refrigeration capacity in single unit.
FEATURES — Unit consists of company's volute-type three-stage compressor, water cooler, condenser and necessary auxiliaries. Features include dual-lubrication system with hermetically-sealed, motor-driven, auxiliary oil pump for starting and emergency service; dual-shaft sealing system, with hydraulic oil seal for operation, and positive-sealing flexible mechanical seal for shut-down periods; stable and efficient operating characteristics from overload down to practically no load; and unusual subcooling system for increased efficiency. Compressors can be driven by steam turbines or electric motors of various types to suit power conditions. These units represent a complete 100% Worthington product when driven by a Worthington-Moore steam turbine, and, if the turbine is of the condensing type, company also supplies steam condenser of the surface or barometric type. If motor-driven, a Worthington-



Moore speed-increasing gear is used, and only major item not furnished by the company is the electric motor.
SIZES AND CAPACITIES—In 56 sizes from 150 to 1150 tons per unit.
LITERATURE AVAILABLE — Bulletin C-1100-B12A.
MADE BY — *Worthington Pump and Machinery Corporation, Harrison, N. J.*

Warm Air Furnace

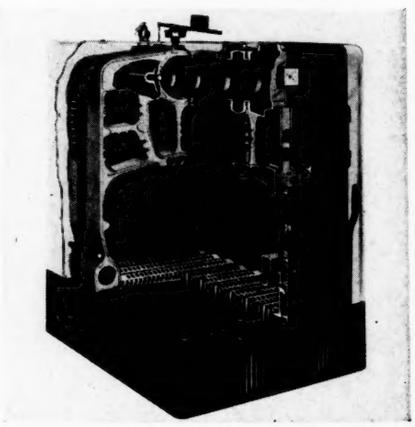
NAME—Fitzgibbons FWA coal-burning warm air furnace.
PURPOSE — Designed for defense housing.
FEATURES — Unit designed in accordance with PBA design described in last month's issue. Jacketed in grey cabinet with black front.
SIZES AND CAPACITIES—80,000 Btu per hr and 6000 cfm of air at ¼ in. static.
MADE BY — *Fitzgibbons Boiler Company, Inc., 101 Park Ave., New York.*

Ventilator Motor

NAME—Ventilator motor.
PURPOSE — A motor for ship generators which fits inside the duct, thus saving valuable deck space, and cools itself by the air displaced by fan.
FEATURES — Motor frame serves double purpose: First, it supports and centers motor in duct; second, supports are shaped like air-foil vanes, straightening air-flow in duct. This lessens turbulence in air, resulting in higher efficiency and quieter operation of blower. Grease pipes and motor leads are brought through one of the vanes, thus eliminating obstruction. Unit consists of Westinghouse motor and Sturtevant blower.
MADE BY—*Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.*

National Series 3 Boiler

NAME—National No. 3 series boiler.
PURPOSE—For large homes and commercial buildings.
FEATURES — An encased type cast iron boiler of the universal fuel type.
FEATURES—Basic design is such that boiler can be used for hand-firing, stoker or oil firing.
SIZES AND CAPACITIES — Available in nine sizes for each fuel with capacities ranging from 168,000 to 552,000 Btu per hr I-B-R rating.
MADE BY — *The National Radiator Co., Johnstown, Pa.*



NEWS FLASH!

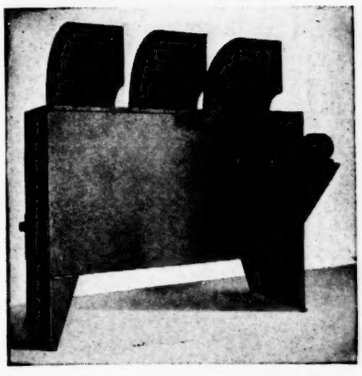
"In future Unit Heaters must have ALL STEEL heating elements. No more copper coils will be permitted, except for Navy ships and overseas bases."

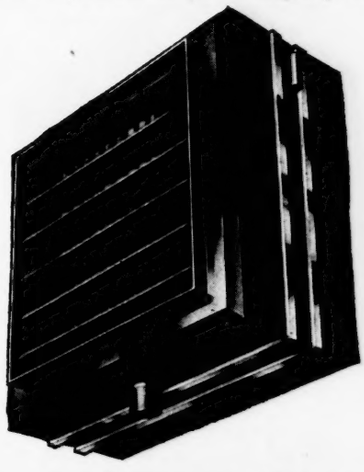
So what? We have always standardized on ALL STEEL elements.

This means to you: you don't have to wait till we have adjusted our production methods. They ARE adjusted. Nothing needs to be changed. WE ARE READY.

The **AIRHEATOR** *Centrifugal Fan Type* *and* **AIRVECTOR** *Propellor Fan Type*

can be supplied in a reasonably short time if you send your inquiry today.





The AIRHEATOR

Centrifugal Fan Type

The Airtherm large capacity Unit Heater for floor or ceiling mounting makes a highly efficient installation. These Heaters have all the rugged construction features found in all Airtherm Heaters, including all-welded joints. They are available in a complete range of sizes for any job and operate quietly and efficiently whether horizontally mounted on the ceiling or placed upright on the floor. Outlet velocities are high enough to insure good heat distribution over large areas, allowing the use of a minimum number of units. This reduces costs and simplifies operation and maintenance of the system.

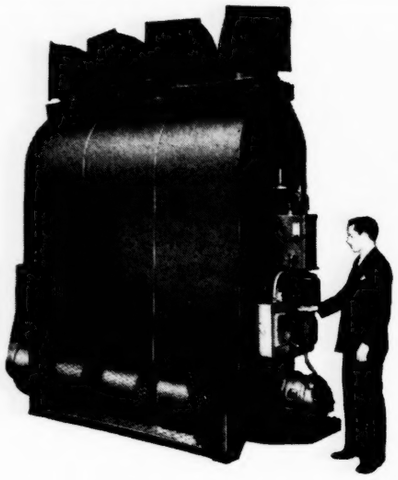
The AIRVECTOR

Propellor Fan Type

A new improved propellor-fan type Unit Heater. The Airtherm Airvector has many exclusive features in design and construction. Materials have been selected for strength and for greatest resistance to corrosion, pressure and temperature. Airvector Unit Heaters have Ribbed Cabinets which make for far greater rigidity and eliminate vibration and "sounding board" action. Motors are mounted with four-point saddle type suspension and cabinets have been redesigned in modern simplicity of line with smooth surfaces. There is a complete range of sizes for maximum efficiency on any job.

Write today for information.

AIRTHERM
MANUFACTURING COMPANY
711 S. SPRING AVE. ST. LOUIS, MO.

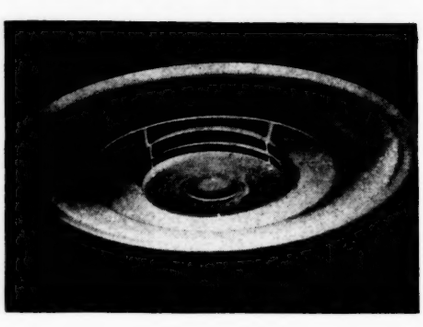


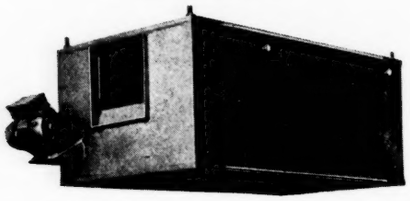
Dravo Heater

NAME—Dravo direct-fired heater.
PURPOSE—For permanent or temporary heating of buildings, particularly those of industrial type.
FEATURES—Heater burns natural or coke oven gas or heavy oil. Device contains its own combustion chamber as well as motors and fans to circulate warm air. Can be connected singly or in series depending on capacity desired. Can be used with top outlets discharging directly into room as illustrated, bottom discharge, or can be connected to central ductwork. Also made in suspended type models.
SIZES AND CAPACITIES—Made in four standard sizes with capacities ranging from 750,000 to 1,500,000 Btu per hr.
LITERATURE AVAILABLE—Bulletin 502.
MADE BY—*Dravo Corporation, Machinery Division, 300 Penn Ave., Pittsburgh, Pa.*

Kno-Draft Diffusers

NAME — Dorex Kno-Draft ceiling diffuser.
PURPOSE—For introducing large volumes of air at high velocities and equalizing room temperature.
FEATURES—A feature is its adjustability. Inner cone assembly may be raised or lowered to vary air direction from vertical to horizontal. In cooling systems inner cone assembly is lowered to obtain horizontal air flow; in heating systems it is raised for a vertical air flow, forcing downward warm air that normally has tendency to stratify at ceiling. This feature is advantageous in rooms with high ceilings. Adjustable feature allows regulation to suit individual job conditions. Device made of steel. Available in unit combining diffused supply air and return or exhaust in one terminal. Also available with built-in direct or indirect lighting.
SIZES AND CAPACITIES — A wide range of sizes and capacities.
MADE BY—*Dorex Division, W. B. Connor Engineering Corp., 114 E. 32nd St., N. Y.*



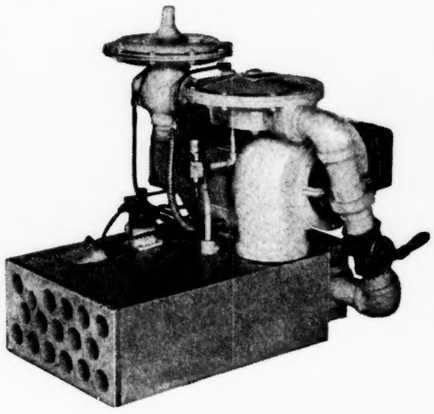


Air Conditioning Units

NAME—Young Streamaire air conditioning units.
PURPOSE—For complete year-round air conditioning, residential or commercial applications.
FEATURES—Device is of the remote unit type, and intended for connection to boiler and cooling systems. Coils will operate in conjunction with steam or hot water for heating and with cold water or direct expansion for cooling. Tempering coils can be installed if desired. Units have spray nozzles or humidifying pans, air filters, and blower type centrifugal fans. Control may be fully automatic.
SIZES AND CAPACITIES — Made in two types, vertical for floor mounting and horizontal for overhead mounting. Made in 8 sizes with wide range of heating and cooling capacities.
LITERATURE AVAILABLE—Catalog 7541.
MADE BY — *Young Radiator Co., Racine Wisconsin.*

Burnham Type R Boiler

NAME—Burnham type R steel boiler.
PURPOSE—For automatic firing, residential applications.
FEATURES — Hot gases travel upward then forward through curved flueways then turn into the center then out to the chimney through series of 2 in. tubes. Choice of hot water heater between tankless heater or storage type coil. Boiler is furnished with insulated steel jacket finished in turquoise blue with black door.
SIZES AND CAPACITIES—Made in three sizes with net ratings from 96,000 to 163,000 Btu per hr.
MADE BY—*Burnham Boiler Corporation, Irvington, N. Y.*

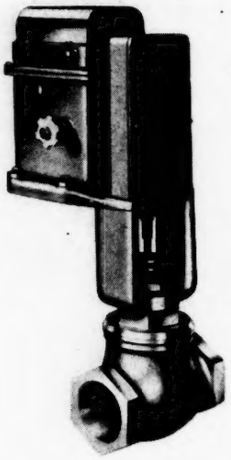


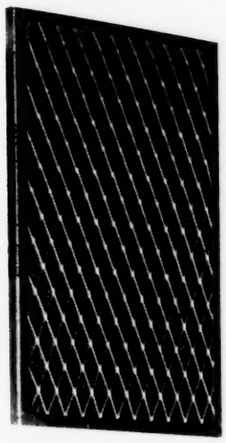
Power Gas Burner

NAME—Lo-Blast power burner.
PURPOSE — For gas firing steam or hot water boilers and furnaces.
FEATURES—Power-type burner with a controlled source of combustion air said to assure high degree of efficiency.
SIZES AND CAPACITIES—Standard models deliver up to 5,000,000 Btu per hour.
LITERATURE AVAILABLE—16-page booklet.
MADE BY—*National Machine Works, 122 S. Michigan Ave., Chicago, Ill.*

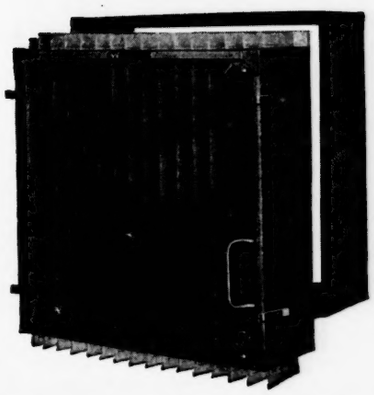
Microvalve

NAME—Microvalve.
PURPOSE — Used for the control of steam, water, oil or gas in air conditioning systems, dryers, and industrial process work where close regulation is required.
FEATURES—A motor-operated valve with proportioning type operator. Valve operator consists of a Microtrol with the addition of an eccentric cam that operates valve plunger. Single seat V-ported, double seat V-ported, and double seat 3-way valve bodies are available.
LITERATURE AVAILABLE—Bulletin F-1420-3.
MADE BY—*Barber-Colman Company, Rockford, Ill.*

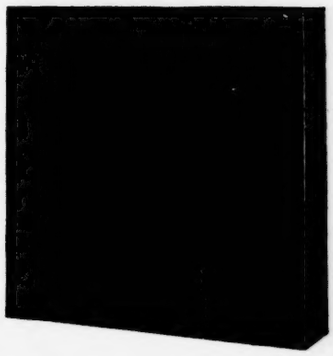




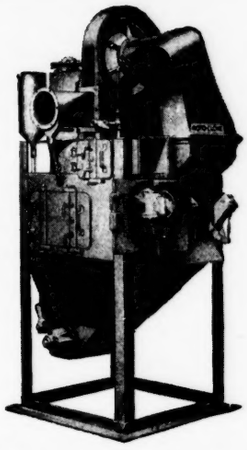
AAF Airplane Engine Intake Filter developed in cooperation with army and aircraft engineers. Bulletin No. 306.



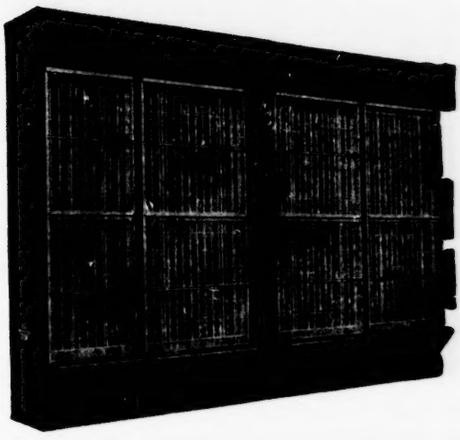
AAF Airmat Dry—Filter extensively used in Ordnance and Powder Plants—approved by National Board of Fire Underwriters. Bulletin No. 230B.



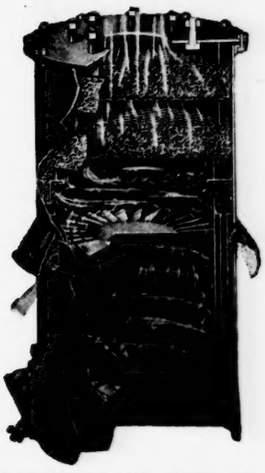
AAF permanent washable viscous unit filters for cargo ships and industrial plants. Ideal for heavy duty service. Bulletin No. 201D.



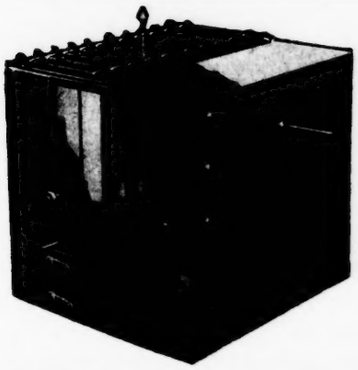
AAF Roto-Clones Type W (wet) and Type D (dry) are used to collect Foundry dusts—and in the machine tool and chemical industries. Bulletin No. 274A.



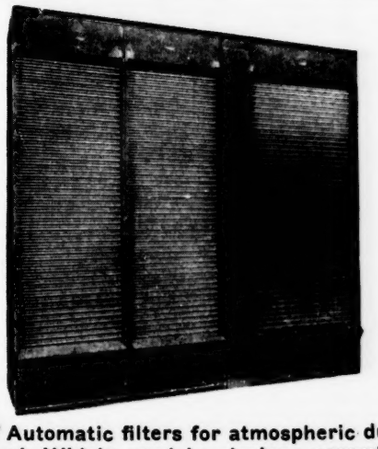
AAF Electro-Matic self-cleaning filter is widely used in aircraft motor manufacturing plants. Bulletin No. 250C.



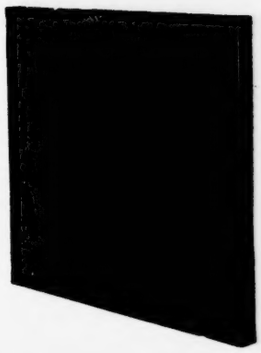
AAF Cycoil air cleaners are used on gasoline and diesel engines and on compressors. Bulletin No. 130C.



AAF Airmat Dust Arrester collects dust from buffing and polishing operations. Used by aircraft engine parts and supercharger manufacturers. Bulletin No. 280.



AAF Automatic filters for atmospheric dust control. Widely used in airplane assembly plants, tank arsenals, etc. Bulletin No. 241.



AAF permanent unit filter for cleaning air supplied to barracks and theatres, in army camps and cantonments. Bulletin No. 201D.

Wherever the countless defense materiel are being made, clean air is playing a vital role in keeping production lines moving at unprecedented speed. Men and women who operate machines must breathe freely of clean wholesome air . . and those machines must be protected from the ravages of abrasive dust. Pictured above are but a few of the American Air Filter products now being used by defense industries . . 92% of our output is being delivered today to companies making war materials. Write for descriptive bulletins to 294 Central Avenue. Canadian companies address—Darling Bros., Ltd., Montreal, P. Q.

THE SYMBOL AAF OF CLEAN AIR

AMERICAN AIR FILTER COMPANY, INC., LOUISVILLE, KY.

Recessed Venturi-Flo

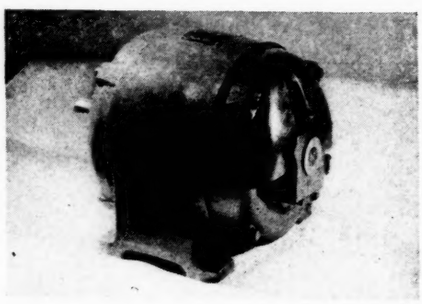
NAME—Recessed type Venturi-Flo.
PURPOSE—Recessed model of company's line of air diffusers.
FEATURES — Spun steel overhead type air diffuser with flow characteristics similar to those of Venturi meter. Relationship between neck area of unit proper and Venturi throat so proportioned as to create slight back pressure in neck at all times, automatically insuring uniform distribution around periphery.
SIZES AND CAPACITIES — A wide range of sizes and special styles permitting handling air volumes up to 15,000 cfm per unit.
LITERATURE AVAILABLE—Bulletin F-1497-2.
MADE BY—*Barber-Colman Company, Rockford, Ill.*

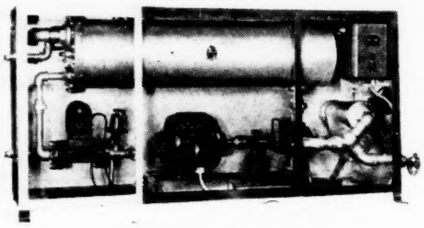
Peerless Dual Pump Drives

NAME—Dual power pump drives.
PURPOSE—A dual drive for Peerless pumps to insure an uninterrupted water supply.
FEATURES—On pumps equipped with electric motor head, a secondary drive may be by right angle gear, which can be powered by gas, gasoline, or diesel engine, or steam turbine. In the event of interruption of electrical service the stand-by pump can be started instantaneously either by the operator or by automatic control.
MADE BY—*Peerless Pump Company, 301 West Avenue 26, Los Angeles, Calif.*

Allis-Chalmers Motors

NAME—Lo-Maintenance motors.
PURPOSE—Motor with complete all-around protection.
FEATURES—"Safety-Circle" is a wide, solid rib, integrally cast as part of the frame, which forms an unbroken circle of protection around the stator. One-piece cast frame and cast end-shields guard the motor from exterior knocks and abuse. Liberal use of electrical materials makes this motor internally and electrically strong because current and magnetic densities are less extreme. Improved bearing design. Rotor is keyed to the shaft for strength, and its outer surface is turned for smoothness and an accurate air-gap. Oil drains at bottom of bearings for easy flushing, removable end-pieces, and large conduit box for handy wiring.
MADE BY — *Allis-Chalmers, Milwaukee, Wisc.*



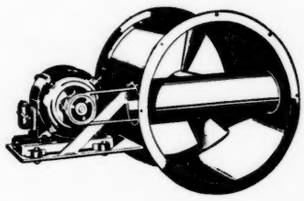


B&G Oil Cooler

NAME—B & G Rapid oil cooler.
PURPOSE — For cooling oil used in quenching steel and other metals.
FEATURES—Affords accurate and automatic control of oil bath temperature essential to obtaining uniform quality in the metal being treated. Large cooling surface provides large capacity in a comparatively small unit. Manufacturer offers complete design and engineering service for cooler installation.
SIZES AND CAPACITIES — Built to any size desired. Self-contained portable units available for plants with small volume of heat treating.
LITERATURE AVAILABLE — Illustrated booklet.
MADE BY—*Bell & Gossett Co., Morton Grove, Ill.*

Leslie Control Pilot

NAME—Leslie control pilot.
PURPOSE—A single seated balanced valve, air operated by control pilot, to maintain constant flow or pressure of fluids.
FEATURES—Device is said to be extremely sensitive and accurate yet ruggedly made. Can be made in large sizes, single seated, so as to be tight if demand of low pressure fluid stops and yet be balanced so as to require little operating power.
SIZES AND CAPACITIES — Made in two types: PR, reverse action, in which a decrease in the control pressure increases the auxiliary pressure; type PD, direct action, in which a decrease in control pressure decreases the auxiliary pressure. Made in a wide range of sizes and capacities.
LITERATURE AVAILABLE — Bulletin 402.
MADE BY—*Leslie Co., Lyndhurst, New Jersey.*

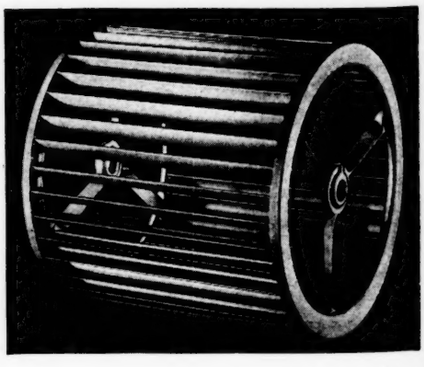


Drum and Drumless Propeller Fans

NAME—Type CS, CSB, CSVB, CSV, and CSBV Propellair fans.
PURPOSE—For air handling.
FEATURES — Type CS is used primarily in corrosive acid fume and alkali conditions while CSV is for use with excessive temperatures. Latter has air cooled bearing, former has not. Both consist of welded drum with front and rear flange with mounting holes for assembly to duct system. Propeller fan mounted inside of drum and driven by motor mounted on outside of drum and connected to fan by belt inside a streamiined tube welded at right angles to drum. Types CSB and CSVB are similar to above, but drumless and units are designed to be installed in existing ductwork. Thus, these units consist of motor, streamlined tube and propeller fan all mounted together. CSVB has air cooled bearings built for use in excessive temperatures while CSB is for acid or alkali conditions.
SIZES AND CAPACITIES—Types CS and CSV made in five sizes ranging from 20 in. to 48 in. in diameter. CSB and CSVB made in five sizes 20 in. to 42 in. in diameter.
MADE BY—*Propellair Inc., Springfield, Ohio.*

Airstream Blower Wheel

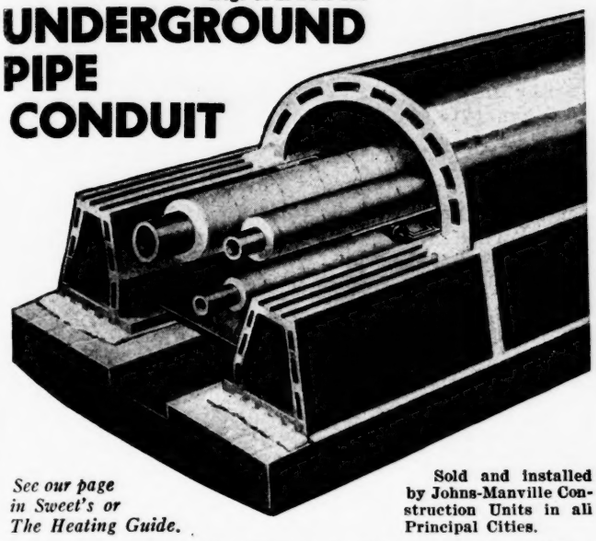
NAME—Airstream blower wheel, addition to line.
PURPOSE—For application to blowers.
FEATURES — Blade section made in one continuous strip from coil stock. Wheel has channel-shaped end rings, stamped metal hubs, and spot-welded assembly. Curved inlets reduce turbulence of incoming air.
SIZES AND CAPACITIES—New addition to line is 14½-inch diameter wheel.
MADE BY—*Morrison Products, Inc., 16816 Waterloo Road, Cleveland, Ohio.*



THERM-O-TILE

Reg. U. S. Pat. Off.

UNDERGROUND PIPE CONDUIT



See our page in Sweet's or The Heating Guide.

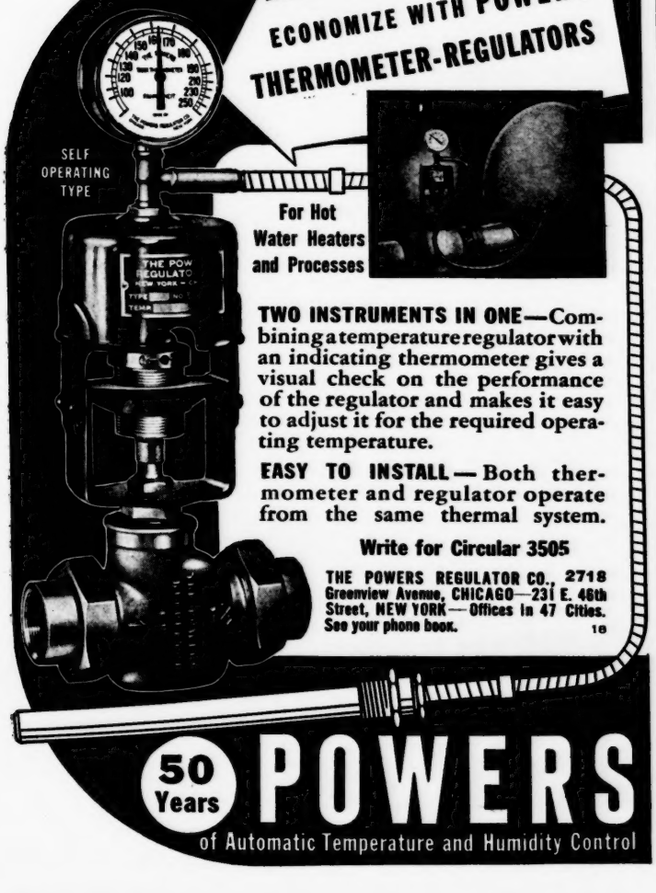
Sold and installed by Johns-Manville Construction Units in all Principal Cities.

Therm-O-Tile is the Simplest, Strongest, Most Efficient, and Only Truly Complete Conduit for Underground Pipe Lines. Unyielding monolithic concrete base. No broken stone fill. No bell joints. Build to correct grade with Therm-O-Tile and that grade will never change. Condensate pockets cannot form. Strong arched construction. Internal channel drain. Etc. Ask for Bulletin 381.

H. W. PORTER & CO., Inc.

823-V Frelinghuysen Ave., Newark, New Jersey

ECONOMIZE WITH POWERS THERMOMETER-REGULATORS



TWO INSTRUMENTS IN ONE—Combining a temperature regulator with an indicating thermometer gives a visual check on the performance of the regulator and makes it easy to adjust it for the required operating temperature.

EASY TO INSTALL—Both thermometer and regulator operate from the same thermal system.

Write for Circular 3505

THE POWERS REGULATOR CO., 2718 Greenview Avenue, CHICAGO—231 E. 46th Street, NEW YORK—Offices in 47 Cities. See your phone book. 18

50 Years **POWERS**

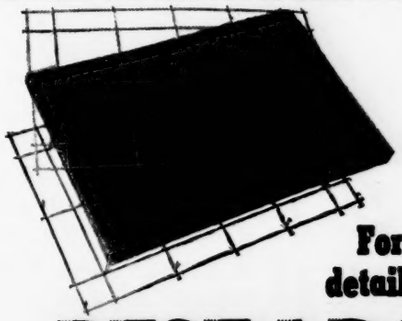
of Automatic Temperature and Humidity Control

Here's How the *New*

RiP-CLEAN Air Filter

Triples Filter Life
Increases Profits
Stops Waste

RiP-Clean Air Filters last three times as long as ordinary filters . . . because clogged filters can be restored to service quickly and easily! When the filter is dirty, the top grid is unhooked and two layers are torn off (as shown above). This cuts down air restriction . . . makes filters last longer — but does NOT reduce dust-catching efficiency. This is the easy, profitable way to service air filter trouble. You get an extra sales point in selling Research RiP-CLEAN Air Filters. Research Air Filters contain a minimum of critical war-time materials. No waste . . . no frame to return.

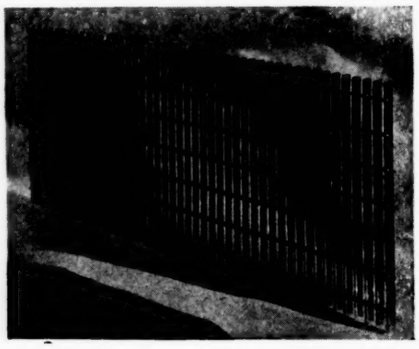


No. 200 Series Re-Fil-Able RiP-CLEAN Air Filter

For full details write

RESEARCH AIR FILTERS

RESEARCH PRODUCTS CORP.
MADISON, WISCONSIN



Uni-Flo Elturn

NAME—Uni-Flo Elturn.
PURPOSE—Used in duct system to eliminate necessity of long radius turns, allowing use of right angle elbows throughout.
FEATURES—Prefabricated of curved turning vanes. Provides uniform air flow around and beyond turn to reduce materially resistance caused by eddies, reverse air flow, and low pressure areas. When used at top of stack heads, device provides straight and uniform air delivery to outlet.
SIZES AND CAPACITIES — Sizes up to and including 48 in. x 48 in. Larger sizes prefabricated in two or more sections assembled into single unit by clamps.
LITERATURE AVAILABLE—Bulletin F-1415-4.
MADE BY—*Barber-Colman Company, Rockford, Ill.*

Infray Paint

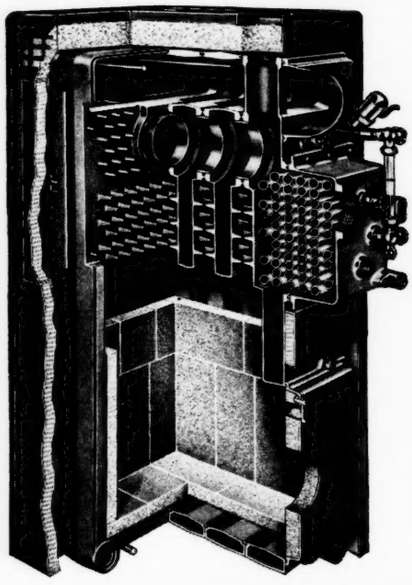
NAME—Infray paint.
PURPOSE—A low visibility paint possessing high heat deflecting qualities for use in protecting concealment of vital defense structures and equipment. Meets tentative Navy specifications for infra-red reflecting paints for use on fuel storage tanks, buildings, and certain types of equipment where dark colors as well as heat reflecting qualities are required.
FEATURES — Offered in green, tan, black, and four intermediate shades. All seven shades are hard to see from the air and reflect most of the heat from the sun's rays that normally would be absorbed.
MADE BY—*The Arco Company, Cleveland, Ohio.*

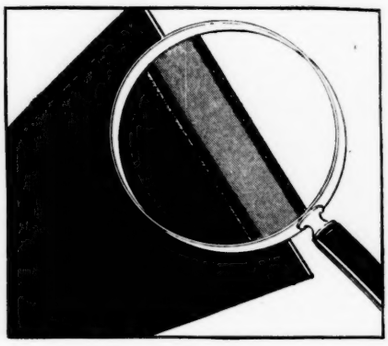
Stoker-Fired Water Heater

NAME—Stokol hot water heater.
PURPOSE—To supply hot water automatically, stoker fired.
FEATURES—Complete self contained unit; occupies small space. Economy claimed due to use of low price fuel. Applicable to great variety of installations. Burns hard or soft coal, and can be used successfully for small house heating.
SIZES AND CAPACITIES — For Bituminous Coal: Model WMB-1, 60 gal per hour, 100F rise; WMB-2, 90 gal per hour, 100F rise. For Anthracite: Model WMA-10, 60 gal per hour, 100F rise; WMA-20, 90 gal per hour, 100F rise.
LITERATURE AVAILABLE — Form 363, Engineering Information; Form 400, Bituminous units; and Form 401, Anthracite units.
MADE BY—Schwitzer-Cummins Co., Indianapolis, Ind.

Spitfire Boiler

NAME—Columbia Spitfire boiler.
PURPOSE—Oil-fired boiler for house installations.
FEATURES—Boiler has the Columbia Aqua-base — a water-backed base that utilizes heat that otherwise would escape. Has ample combustion space, easily replaceable combustion chamber lining of standard fire bricks; Turbulator baffles with fin studded heating surface; and inch-thick aircell insulation. Has tankless heater for hot water supply. Jacket in green and black.
LITERATURE AVAILABLE—Bulletin G-23.
MADE BY—*Columbia Radiator Company, McKeesport, Pa.*





Pitch-On-Metal

NAME—Pitch-On-Metal.
PURPOSE—A substitute material for use in place of sheet metals for ducts, termite shields, gravel stops, etc.
FEATURES—Said to have strength of steel and flexibility of copper. Made with a ferrous metal core, completely enclosed in a baked-on coal-tar pitch. Said not to be affected by moisture or cement mortar, and resistant to most acid conditions. Can be satisfactorily painted any desired color provided one coat of shellac is applied after fabrication is completed.
MADE BY — *The Cheney Company, Ardmore, Pa.*

High Pressure Try-Cocks

NAME—Yarway heavy-duty try-cock.
PURPOSE—For high pressure steam boiler application.
FEATURES—Easy to operate, said to shut off tight with no dripping. To avoid interference of operating chains, operating lever on upper cock is offset outward. Lever on center cock is straight and lever on lower cock is off-set inward. Also made in weighted lever style with single operating chains.
SIZES AND CAPACITIES—For pressures up to 600 lb, body and stem are Tobin bronze; from 600 to 1500 lb, body and stem are stainless steel.
LITERATURE AVAILABLE — Catalog WG-1808.
MADE BY—*Yarnall-Waring Company, Chestnut Hill, Philadelphia, Pa*

Aqua-Clear

NAME—Aqua-Clear.
PURPOSE—Liquid to prevent rust and provide clear water from metal tanks or pipes. Also to clear out loose rust from old tanks and pipes.
FEATURES—Product is clear, tasteless, harmless liquid to be added in minute quantities to the water as it is being put into the system. Operates by forming a deposit of a thin, nonpermanent film on metal surfaces. Can be added manually or with a proportioning device. One ounce to each 100 gal. of water is recommended for average cases.
MADE BY—*Sudbury Laboratory, South Sudbury, Mass.*

De-Sta-Co
Blower Wheel Housings

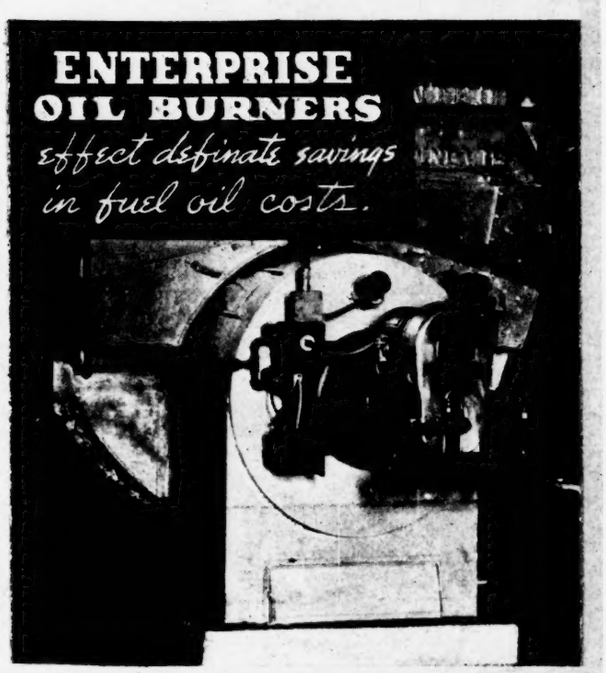
of Standard Dimensions

Made in sizes to fit 4½, 5, 6, 7½ and 9 inch wheels and in widths to suit single or double inlet wheels . . . also individual parts for your own assembly.

De-Sta-Co housings are engineered for maximum efficiency and quietness in operation . . . neatly finished. Send for "De-Sta-Co Blower Housings" bulletin; gives complete information, including essential dimensions.

DETROIT STAMPING CO.
Established Over 25 Years
375 Midland Ave • Detroit, Mich.

ENTERPRISE
OIL BURNERS
effect definate savings in fuel oil costs.



ENTERPRISE
ENGINE AND FOUNDRY CO.
18TH & FLORIDA STS.
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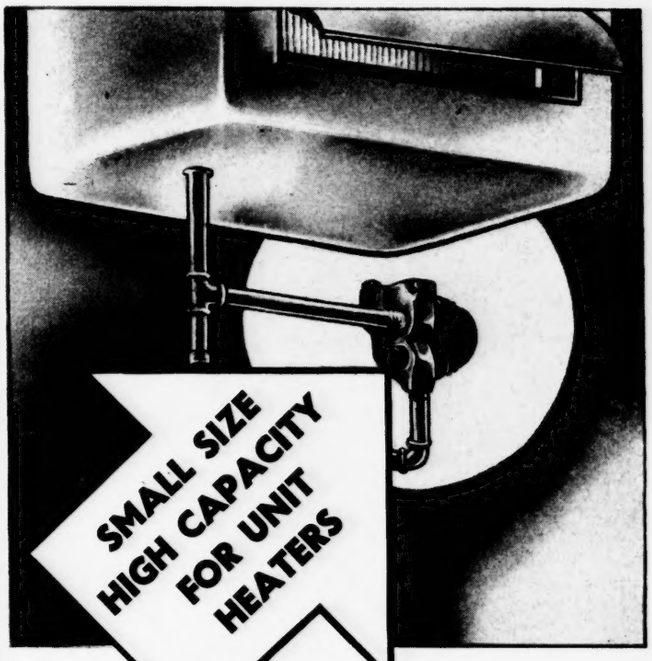
DISTRIBUTORS IN PRINCIPAL CITIES



Saves on Installation Costs

STERLING
No. 69-A

Float and Thermostatic Trap

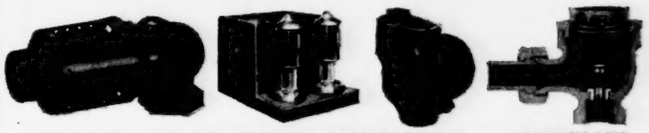
Why use expensive, "bulky" Float and Thermostatic Traps on your Unit Heater installation, when the compact, quick operating Sterling No. 69 F & T Trap will do the job! Weighs only 7 pounds, measures 3 x 5 x 5 inches—yet handles over 1300 lbs. of condensate per hour at 20 lbs. pressure.

Saves on piping and installation time by providing four methods of connection—with two steam inlets, two return outlets. Easy to clean—without disturbing piping —by merely removing four capscrews.

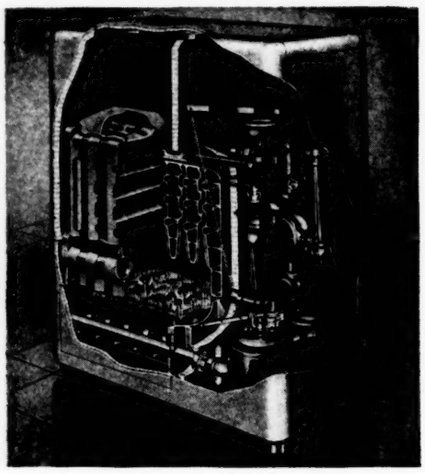
Use this compact, efficient trap on the numerous installations that its high capacity permits. Its unobtrusive size will improve the neatness of the entire Unit Heater installation; and will offer you remarkable savings in initial cost and maintenance.

Jobbers and Contractors!
Write for further data and prices!

STERLING, Inc.
3732-B N. Holton St., Milwaukee, Wis.



STERLING—QUALITY HEATING SPECIALTIES . . . CONDENSATE PUMPS, TEMPERATURE CONTROLS.

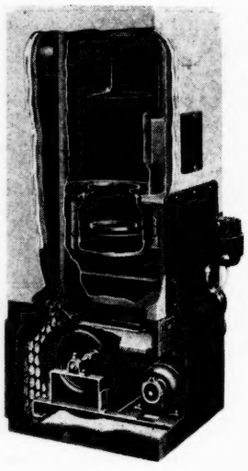


National Gas Boiler

NAME—National No. 20 series gas-fired boiler.
PURPOSE—Steam or hot water heating.
FEATURES—Boiler is cast iron encased type with low water cut-off and other controls. Outstanding feature is draft divertor concealed in cabinet.
SIZES AND CAPACITIES—From 170 to 2250 sq ft of steam or 270 to 3600 sq ft of hot water radiation.
MADE BY — *The National Radiator Co., Johnstown, Pa.*

Airtemp Oil Furnace

NAME—Chrysler Airtemp Vapor-Flame oil furnace, models EO-6, EO-7, and EO-8.
PURPOSE—Automatic heating for small houses costing $6000 or under.
FEATURES—Offered in three models —one a gravity type, second a forced type with humidifier and third, a forced unit with filters and humidifier.
SIZES AND CAPACITIES—Measures 24 in. square, 65 in. high, with capacities as follows: EO-6, 50,400 Btu per hr.; EO-7, 50,500 Btu per hr; EO-8, 56,000 Btu per hr. Furnace weighs 253 lb.
MADE BY—*Chrysler Airtemp, Airtemp Division, Chrysler Corporation, Dayton, Ohio.*

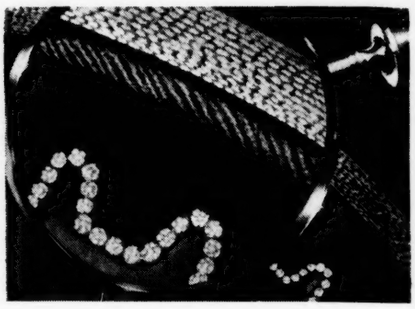


Rock Wool Pipe Covering

NAME—No. 100 pipe covering.
PURPOSE—For pipe insulation. Particularly adaptable for long runs of overhead or underground steam lines.
FEATURES—Covering is fabricated of high temperature moisture resistant rockwool held together by expanded metal lath on the outside and by strips of lath on the inside, spaced approximately 2 in. apart. Covering packed in flat sheets cut to size so that it can easily be wrapped around the pipe. Edges of the lath are brought together by lacing 18 gauge soft wire through the mesh of the lath. On long outside runs 28-gauge galvanized sheets are recommended for outside covering; for underground service 45 lb roofing felt held in place by 16 gauge copper-weld wires are recommended as outside covering. Covering has a thermal conductivity of 0.36 Btu per sq ft per degree at a mean temperature of 200F and a coefficient of 0.55 at 500F. Water absorption tests show 7.9% of water is retained immediately after immersion and none retained after draining for 20 hours. Tests show alkalinity of 0.18%.
SIZES AND CAPACITIES—Available in five thicknesses, ranging from 1 in. to 3 in. depending on the temperature of the medium in pipe, the 1 in. being for from 212 to 250F and the 3 in. from 850 to 1000F.
MADE BY—*Baldwin-Hill Company, Trenton, N. J.*

Dri-Air Moisture Absorber

NAME—Dri-Air chemical powder and Dri-Air container.
PURPOSE — For absorbing moisture from the air, basements, closets, laundry rooms, dark rooms, and similar places.
FEATURES—The company is offering a one-piece triple-V-shaped basket that holds ten pounds of a chemical powder which has the property of absorbing moisture from the air and depositing the drippings in a metal pan below the basket. As the powder is used up more powder can be added at the top. Manufacturer recommends that liquid drippings should be saved to be used for melting ice on slippery sidewalks, eaves and waterpipes, for settling dust in gravel driveways, and for killing weeds.
SIZES — One container recommended for each 800 to 1000 cu ft of space. Basket holds 10 lb of powder which will dissolve from 10 to 30 lb of moisture from the air depending on the temperature and humidity.
PRICE — Container sells for $3; ten pound bags are listed at 70 cents and 100 lb bags at $5.50.
MADE BY — *Tamms Silica Company, 228 North La Salle Street, Chicago, Ill.*

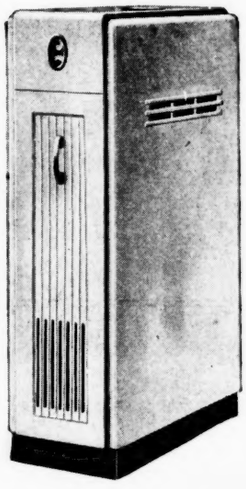


V-V or V-Flat Cog Belt

NAME—Dayton Cog-belt.
PURPOSE—A new belt on the cog principle for V-to-V or V-Flat service.
FEATURES — Cog construction consists of patented die cut raw edges for greater gripping power; new flat tooth cog-construction, gives greater pulling power on flat pulley surface. V-Flat drive said to afford quick and economical change-over for converting equipment with short-center V-belt drive.
SIZES AND CAPACITIES — In all standard lengths in A, B, C, D, and E cross-sections and in matched sets for multiple drive service.
MADE BY—*The Dayton Rubber Manufacturing Company, Dayton, Ohio.*

Richmond Gas Boiler

NAME — Richmond Heatomat gas boilers.
PURPOSE—For steam, water or vapor heating.
FEATURES—Cast-iron sections are of vertical tubular construction on Scotch marine principle. Water jacketed wall surrounds burners along entire length. Has steel casing, finished in baked enamel and lined with asbestos.
SIZES AND CAPACITIES — Twenty-five sizes from 430 to 18,600 sq ft of water or 390 to 11,625 sq ft of steam radiation.
MADE BY—*Richmond Radiator Company, Inc., Uniontown, Pa.*



YARWAY GUN-PAKT EXPANSION JOINT

It is packed under full steam pressure. By the turn of a wrench, integral pressure guns force a special semi-plastic packing into the stuffing box.

Welded Steel Construction. Alemite lubricated cylinder-guided sleeve. Made also in conventional gland-pakt types. Write for Bulletin EJ-1907.

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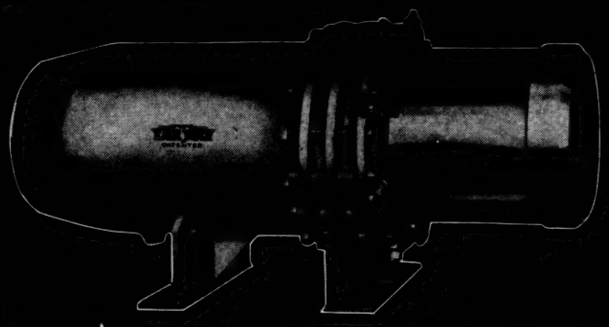
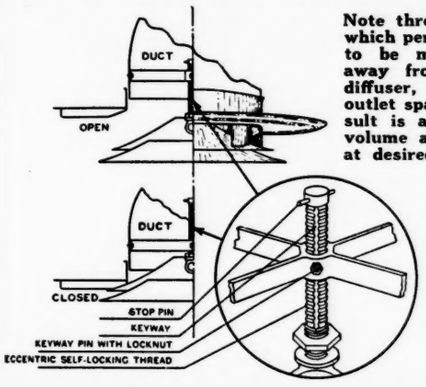
YARNALL-WARING COMPANY
104 Mermaid Ave. PHILADELPHIA



DEMUTH
New Positive Control Feature

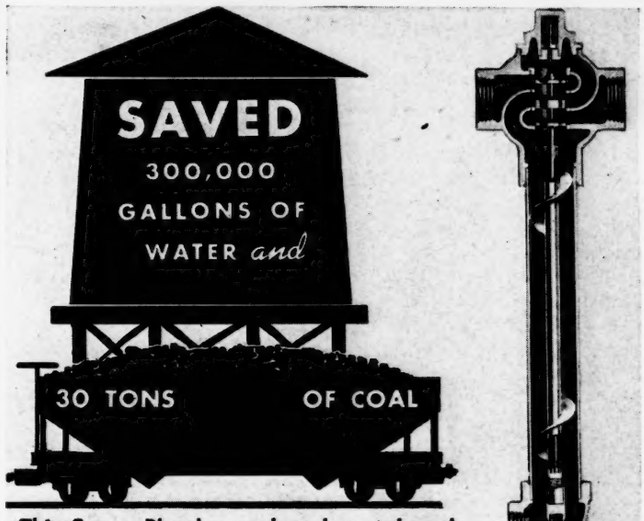


Note threaded arrangement which permits conical vanes to be moved towards or away from upper part of diffuser, thus varying the outlet space at will. The result is absolute control of volume and velocity of air at desired point.

DEMUTH Draftless Air Distributors

—improve any Industrial Air Conditioning job. Features include *Rotary* Circulation and recirculation, extreme simplicity of operation and installation, adaptability to lighting fixtures, plus new Positive Air Volume Control and riveted construction for every industrial, marine and Defense application. Specialized experience makes Demuth Service valuable to engineers and contractors in Defense installations.

CHARLES DEMUTH AND SONS
New Hyde Park Box 74, Garden City Park, N. Y.



This Sarco Blender replaced a stokered boiler and saved 30 tons of coal and 300,000 gallons of water per month. It uses compressor cooling water formerly wasted and provides hot water for showers and heat for a wash room accommodating 200 miners in three shifts a day. Besides saving an investment of $1,050 in boiler equipment, this arrangement gives excellent service, eliminating entirely the complaints that were a daily occurrence before. Catalog No. 800 lists all Sarco Mixing Valves.

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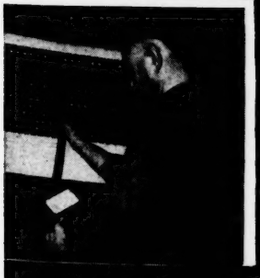
SARCO
SAVES STEAM

SARCO COMPANY, INC.
475 Fifth Avenue, New York, N. Y.
SARCO CANADA LTD., FEDERAL BLDG., TORONTO, ONT.

The All Purpose



AIR VELOCITY METER

Alnor VELOMETER

INSTANTANEOUS DIRECT READING
ASK FOR BULLETIN 2408D

Illinois Testing Laboratories Inc
143 W. HUBBARD ST., CHICAGO, ILL.

SOMERS HAIR GLASS FILTER "V" type

INDUSTRIAL AIR CONDITIONING Needs SOMERS HAIR GLASS FILTERS

Somers Filters are built with frames of galvanized metal, packed with Hair Spun Glass — washable — odorless — non-absorptive — non-rotting — and are practically indestructible.

Dust, dirt, pollen, detritus and industrial wastes in the air stream effectively removed with minimum back pressure. No adhesives required.

Made in every size required for industry. In use in a wide range of factory applications, for chemical, textile, and metal-working installations where precision is a factor.

Quotations supplied on receipt of c.f.m. per unit and dimensions of master holding frames. A few choice territories open for qualified representatives.

H. J. SOMERS, INC., 6067 WABASH AVE. DETROIT, MICH.

ASHVE Convention Report

(Concluded from page 64)

They also pointed out that the critical point of dryness is at 0.4 in. Hg. vapor pressure. Below this the throat surface and membrane are definitely dry. However, the authors emphasized that there is no direct evidence that the drying of the mucous surfaces is actually undesirable. The general opinion that very dry air irritates the throat and the clinical practice of treating the membranes of persons suffering from bronchial disease by soothing inhalations would seem to suggest that the problem may be of importance. If dry air is harmful, it seems obvious that its influence must be present, not merely in hot, dry air, as has often been thought, but quite as much in cold, dry air. Furthermore, it appears that, if it is desired to control the influence of dry air on the mucous membranes, a relatively high vapor pressure must be maintained corresponding at 70F to over 50 per cent of saturation.

"Pressure Loss Caused by Elbows in 8-Inch Round Ventilating Duct" is the title of a paper by Prof. M. C. Stuart, C. F. Warner and W. C. Roberts, all of Lehigh University. The paper is the result of research sponsored by the Society in cooperation with Lehigh University. Significant conclusions arrived at from the data presented by the authors included the following:

Pressure loss caused by elbows is proportional to the 1.84 power of the velocity.

The pressure loss of an elbow at any velocity may be expressed by a unique equivalent length of straight duct.

Splitters reduce the pressure loss in elbows of small radii. One splitter in a 2-in. inside radius elbow reduces the loss 20%; one in the miter elbow reduces the loss 40%.

A Research Laboratory report by Dr. Houghten and Messrs. Taimuty, Gutberlet and C. J. Brown, on "Heat Loss Through Basement Walls and Floors," was presented by Dr. Houghten. The paper showed that there was a large discrepancy between the actual heat lost and that calculated by various methods. So far as actual application of the information in the paper is concerned, however, Dr. Houghten pointed out that the heat loss in any case depends to a great extent on the characteristics of the earth, ground, water level and other variables in any given case.

Other papers included the following: Periodic Heat Flow in Building Walls Determined by Electrical Analogy Method; Heat Gain Through Walls and Roofs as Affected by Solar Radiation; Effect of Attic Fan Operation on the Cooling of a Structure; Factors Influencing the Heat Output of Radiators; Corrosion Tests in a Water Recirculating Air Conditioning System; Determining Sound Attenuation in Air Conditioning Systems; Physiological Fatigue From Exposure to Hot Environments; and Observed Performance of Some Experimental Chimneys.

A feature of the annual banquet was the presentation of the F. Paul Anderson Medal to Dr. F. E. Giesecke, professor emeritus at the A. and M. College of Texas, and past-president of the ASHVE. The committee on award honored Dr. Giesecke for "his notable contributions to the advancement of heating based on his research work in the fields of heat transfer and hot water heating, and for his eminent services to the Society as a member and officer."

Another feature of the banquet was the presentation of the past-president's emblem to Walter L. Fleisher, New York, N. Y., retiring president of the Society. The presentation was made by W. H. Driscoll, Syracuse, N. Y., also a past-president of the ASHVE. The toastmaster at the banquet, A. J. Nesbitt, of Philadelphia, introduced the newly-elected officers as follows: Prof. E. O. Eastwood, Seattle, Wash., president; Merrill F. Blankin, Philadelphia, first vice-president; S. H. Downs, Kalamazoo, Mich., second vice-president; and E. K. Campbell, Kansas City, Mo., treasurer.

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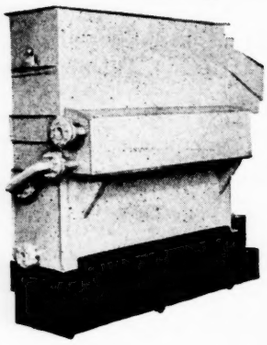
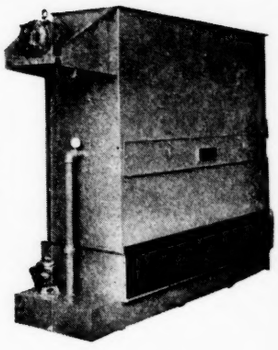
... that Save Money in Industrial Applications

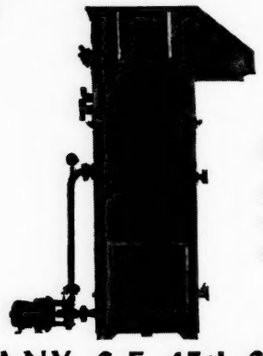
NIAGARA *Duo-Pass* EVAPORATIVE CONDENSERS
for industrial refrigeration lower condensing temperature, save power and water, increase the life of equipment.



NIAGARA EVAPORATIVE LIQUID COOLERS
save power and prevent troubles in jacket water cooling, quenching oils, industrial fluids.



NIAGARA *No Frost* METHOD
with Spray Coolers protects quality in fresh and frozen foods, saving power and equipment cost without icing of coils in sub-zero temperatures down to –50° F.



NIAGARA *Type* A CONDITIONERS
give precise control of temperature and humidity for processing hygroscopic materials.

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NEW TRADE LITERATURE

Air Outlets. A standard size 20-page bulletin devoted to the company's Aerofuse outlets and profusely illustrated with detailed drawings including special adaptations, engineering data, accessories, tabulations for selection, and performance. TUTTLE & BAILEY, INC., NEW BRITAIN, CONN.

Condensate Return. Cochran Corporation, Philadelphia, has announced a four-page, standard size bulletin 3025, covering the Cochrane-Becker high-pressure condensate return system. Lists industries in which system is applied, describes a typical installation in detail, and shows drawings illustrating operation of the jet-loop principle on which the system operates. Includes detailed engineering specifications. COCHRANE CORP., PHILADELPHIA, PA.

Welding. A detailed description of the activities of the five companies which comprise Air Reduction Company, Inc., illustrated both with pictures and diagrams and completely describing the methods, the markets and the nature of the business. Purpose of the book is to acquaint stockholders and others with what Air Reduction does, and give a full and complete description of the thousands of uses to which the company's products are put. Many of these products are also playing a vital part in numerous industries now in the forefront of national defense—for instance, shipbuilding, aviation, explosives, manufactured gas, sheet metal products and steel works and rolling mills. The trade names under which these products are marketed are often not identified with any of the five Airco operating companies, namely, Air Reduction Sales Company, National Carbide Corporation, Wilson Welder and Metals Co., Inc., Pure Carbonic, Incorporated, and The Ohio Chemical & Mfg. Co. Book is 54 pages, elaborately illustrated and flexibly bound. AIR REDUCTION SALES CO., 60 EAST 42ND ST., NEW YORK.

Instruments. Bulletin 585 containing a condensed index of Bristol products manufacture and of its Engineering services. Also covers air-operated and electrically operated automatic control instruments, recording and indicating instruments, and telemetering instruments for recording and remote automatic control. THE BRISTOL CO., WATERBURY, CONN.

Paints. A file folder of data sheets on the widely Used Army and Navy specification finishes so that the user can keep in a convenient place government specification finishes usually identified only by code numbers. ROXALIN FLEXIBLE LACQUER CO., BOX 511, ELIZABETH, N. J.

Structures. An eight-page bulletin entitled "How to Assemble Lindsay Structure." Lindsay Structure is a light-steel, prefabricated construction which can be used for such purposes as truck bodies, industrial buildings, ovens, and unit coolers. Booklet gives complete details, in words and pictures, of procedure of assembling structure. DRY-ZERO CORP., 222 N. BANK DRIVE, CHICAGO.

Unit Heaters. A series of four standard size single sheets of specifications covering the company's types 46, 46P, 46Q, and 46R air diffusers. CARRIER CORPORATION, SYRACUSE, NEW YORK.

Bearings. A standard size catalog L-3, 36 pages, devoted to the company's Ledaloyl self-lubricating bronze bushings and bearings. Lists over 2000 sizes. JOHNSON BRONZE COMPANY, NEW CASTLE, PA.

HE CHANGED THE AIR IN MEDICAL SQUARE!

J. W. MERRIAM *(left)*, head of the Pacific Ventilating and Air Conditioning Co., Los Angeles ... specialist for more than 20 years in ventilation of industrial plants and commercial buildings ... now "up to his ears" in government and war business. He specifies ILG equipment exclusively.

THE FORTY DOCTORS in Medical Center, Los Angeles *(above)*, wanted cooler offices, better ventilation. Mr. Merriam was consulted ... eventually installed an ILG system of highly efficient ventilating and cooling, using ten 24-inch ILG Power Roof Ventilators, two on each building.

"AS CLOSE TO BEING PERFECT as possible," says C. C. Glass, Manager of Medical Square, referring to ILG equipment installed 2 years ago. Heat, odors, and stale air driven out, fresh air drawn in ... for year 'round comfort and health.

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Ask for No. 141

POSITIVE ALL-WEATHER VENTILATION—Powerful ILG Self-Cooled Motor Propeller Fan in weather-tight penthouse assures quick, positive ventilation under all weather conditions. Exclusive self-cooled motor that "breathes"—never over-heats, is not affected by moisture condensation, lowers operating costs.

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OFFICES IN 43 PRINCIPAL CITIES **CONSULT YOUR PHONE DIRECTORY**

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Vitalized Ventilation
AND AIR CONDITIONING
AIR CHANGE ... NOT JUST AIR MOVEMENT!

For Important Defense Projects Engineers Specify

ADSCO

BANNON CONDUIT

REASONABLE
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EASY TO INSTALL
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PROMPT SHIPMENTS

These three advantages make ADSCO-Bannon Tile Conduit a big favorite for the steam and hot water lines of army camps — naval and air bases, defense plants and housing projects.

Available with or without base drain, in sizes from 4 - 24" inclusive. With ADSCO Filler Insulation—a "Fiberglas" product, it makes a permanent installation of high thermal efficiency. Submit details of proposed installation for prompt quotation or write for illustrated bulletin 35-67V.

AMERICAN DISTRICT STEAM COMPANY NORTH TONAWANDA, N. Y.

Making "UP-TO-DATE" Steam Line Equipment for over 60 years

PERSONALS & PERSONNEL

Maj. Homer Hosking

Major Homer Hosking, manager of the New York office of the Pacific Steel Boiler Division, U. S. Radiator Corporation, a soldier with a distinguished World War record, has been promoted to a Lieutenant Colonelcy in the New York State Guard. Lt. Col. Hosking is in the engineering corps of the State Guard, and is assigned to the staff of the commanding officer, *Major General W. I. Ottman.* He has been associated with the U. S. Radiator in sales, engineering and management divisions.

Ilg Electric Ventilating Co., Chicago, has named *Byron L. Casey* of the Chicago city sales office as district manager of the Northern territory, supervising branch offices in Chicago, Milwaukee, Minneapolis, Galesburg and South Bend; *Wallace G. Burbo* has been appointed manager of the Boston branch office; *Charles E. Parks,* formerly manager of the Pittsburgh branch office, has been transferred to Los Angeles, where he will assume new duties as district manager of the Pacific Coast territory. Branch offices in Los Angeles, San Francisco, Seattle, Salt Lake City, San Diego, Phoenix and El Paso will be under his supervision; *Charles H. Schneider,* formerly in the Philadelphia branch office, assumes the post vacated by Mr. Parks, as manager of the Pittsburgh branch office. The Pittsburgh office now becomes a part of the Middle Atlantic territory, under the supervision of *C. W. Smith* at Philadelphia; in Houston, Texas, *W. M. Vernor* has been placed in charge of the branch office under the jurisdiction of *Joseph J. Friedler,* manager of the Southern territory.

Hubert Kaub, 1029 Santa Fe Drive, Denver, Colo., has been appointed representative to cover Colorado, Wyoming and New Mexico for Research Air Filters Corporation, Madison, Wis.

Ralph J. Lundrigan has joined the Cochrane Corp., Philadelphia, to supervise the merchandising of the Cochrane-Becker high-pressure condensate return system.

Buensod-Stacey Air Conditioning, Inc., 60 East 42nd Street, New York, announces that *M. S. Smith* has been elected vice-president in addition to continuing as general manager. *W. J. McDonald* was elected treasurer to succeed Mr. Smith in this function.

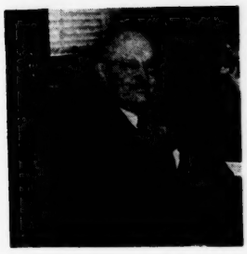
A. E. Stacey, Jr., of the firm is now a commander in the U. S. Navy and is on active duty somewhere in the Pacific. Mr. Stacey has resigned as officer and director of the organization for the emergency period.

Modine Manufacturing Company, Racine, Wis., has appointed *Chas. R. Hiers* as representative in the New York City sales area with headquarters at Room 1734, Architects Building, 101 Park Avenue.

Walter A. Bowe, advertising and public relations manager of Carrier Corporation, Syracuse, N. Y., has been elected director-at-large of the National Industrial Advertisers Association, Inc., to fill the unexpired term of *R. D. Hawkins* who has resigned.

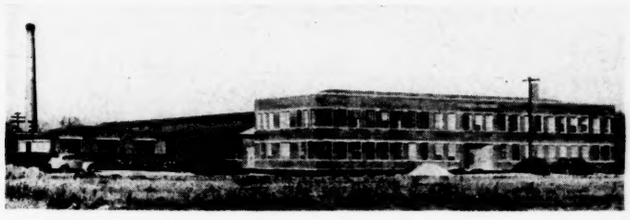
The B. F. Goodrich Co., Akron, Ohio, has combined its former mechanical goods and sundries sales and formed the Industrial Products Sales Division. The set-up under the new policy is as follows: *B. F. Stauffer*, division assistant general manager in charge of Miller plant activities; *L. H. Chenoweth*, manager, manufacturers' sales; *C. F. Conner*, manager, distributor sales; *C. O. Delong*, manager, operations, and the following department managers: *P. W. Van Orden*, hose and belting; *J. F. Johnston*, molded, extruded, sponge, Anode dipped goods; *G. K. Ryan*, rubber and latex thread, golf ball products; *H. C. Klein*, rubber lined and covered equipment; *F. A. Lang*, shoe products sales; *J. M. Failey*, printing rubber, printing rolls, printing blankets, platens, packings, floor coverings, lathe cut goods; *H. A. Bauman*, bands, drug, hospital and surgical products.

WITH THE MANUFACTURERS



Earl J. Gossett, president

Bell & Gossett on January 10 opened its new factory at Mendota, Ill. *E. J. Gossett*, *R. E. Moore*, and *C. E. Pullum* played host to over a thousand guests. To avoid confusion and because the factory has a large volume of Army and Navy contracts, visitors were conducted through the plant in guided groups. The 70,000 square foot area of the plant is now in full operation, turning out the company's forced hot water heating systems, water heaters, and heat transfer equipment for a wide variety



Exterior view of the new Bell & Gossett factory at Morton Grove, Ill.

of uses. One of the high spots of interest was the Monoflo fitting machine, shown in operation. This machine taps the threads with such accuracy that installation and perfect alignment are easy.

Jenkins Bros., 80 White Street, New York, announces that it has increased its productive capacity of corrosion-resisting alloy valves so as to offer faster delivery. In addition, the line of globe, angle, Y and check valves has been augmented by solid wedge and double disc-taper seat gates in sizes to 6 in. and that it has begun an innovation, "Certified Castings," each casting being x-rayed as well as pressure-tested. Descriptive booklet SS is offered.

A change of name has been announced by *Surface Combustion Corporation*, Toledo, Ohio, which, effective January 1, 1942, is now *Surface Combustion Division of General Properties Company, Inc.* According to an announcement from the company the change will not affect the present organization, method of operation or relations with customers. Company will continue to operate as a separate unit but as a division of the parent company instead of as a subsidiary.

VICTORY..
24-hour-a-day Job for REFRIGERATION and AIR CONDITIONING

Refrigeration and Air Conditioning, for so many years charged with the responsibility of our Nation's Health and well-being, today find that responsibility increasing in importance. For soldiers and sailors in training and on battle fronts, and millions of workmen in Defense factories need every last ounce of vigor and energy to carry them through the emergency. And food and food protection alone gives them "health-insurance" against the rigors of long hours and consecrated effort in the cause of National security.

Today there's no time for equipment shutdown. No excuse for equipment inefficiency. . . . And present equipment must be kept operating, that new equipment needs and replacements be kept at a minimum. THAT is a task for A-P DEPENDABLE VALVES, accurate, DEPENDABLE Refrigerant Control that helps keep equipment up to peak efficiency and in constant, trouble-free operation . . . a task that A-P Valves have successfully accomplished through many years of use on Refrigeration and Air Conditioning installations of all types.

We gratefully dedicate our efforts to the "24-hour-a-day" Efficiency that VICTORY requires of Refrigeration Equipment.

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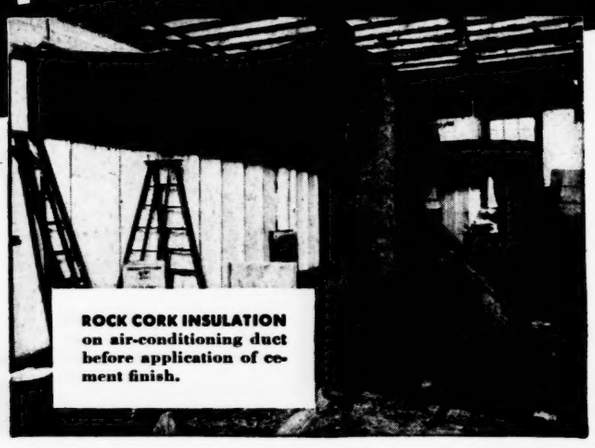
A-P DEPENDABLE Refrigerant Valves

In every low-temperature insulation service

J-M ROCK CORK DOES THIS THREE-WAY JOB



ROCK CORK INSULATION on air-conditioning duct before application of cement finish.

Rock Cork provides permanent efficiency! Unusually moisture resistant, minimizes moisture infiltration . . . the cause of most low-temperature insulation failures. Installations made many years ago still retain their high insulating effectiveness . . . show no signs of deteriorating.

Rock Cork provides installation savings! Light in weight and easy to handle, Rock Cork can be quickly applied. On the job, costs stay low. For Rock Cork is basically mineral . . . rotproof, unusually durable. Little maintenance is required.

Rock Cork provides low initial costs! You pay no more for Rock Cork than for other low-temperature insulations. And you're sure of complete uniformity, for Rock Cork is made to an exact formula under rigid laboratory control.

You should have all the facts on the advantages J-M Rock Cork offers for use on refrigerating equipment, cold lines and air-conditioning ducts. Write for brochure DS-555. Johns-Manville, 22 East 40th Street, New York, N. Y.

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JM ROCK CORK

LOW-TEMPERATURE INSULATION. IN SHEET FORM AND FOR PIPE COVERING

Airtemp Division, Chrysler Corp., Dayton, Ohio, has launched a broad-gauge dealer program aimed at building an organization better able to serve the country's war effort. *Paul B. Zimmerman,* vice-president and general sales manager, takes the position that in the company's efforts to employ its facilities to best advantage in the nation's victory program, dealers are as important as the factory itself. Further, air conditioning has been found essential to many manufacturing operations and processes vital to war production, and Airtemp dealers are being urged to make units available to defense plants where control of temperature and humidity is necessary.

COMING EVENTS

MAY 24-29. 53rd annual meeting of the Heating, Piping and Air Conditioning Contractors National Association, Hotel Schroeder, Milwaukee, Wis.

JUNE 10-12. 33rd annual meeting of the National District Heating Association, Dayton, Ohio. Further information from John F. Collins, Jr., secretary, NDHA, 827 N. Euclid Ave., Pittsburgh, Pa.

WEEK of JUNE 14. Semi-annual meeting, American Society of Heating and Ventilating Engineers, Hotel St. Paul, St. Paul, Minn.

NOZZLES for Air Washing

Yarway Involute Design—with no internal parts or vanes — insures non-clogging trouble-free service. Sizes and types to meet all requirements. Successful installations of Yarway Involute Nozzles in water cooling and air conditioning service total more than 5 million gallons per minute. Write for Bulletin N-615.

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H. & V.'s Reference Section No. 1. Practical information on design and construction of radiant heating systems, with examples of modern installations. Price, 25c.

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H. & V.'s Reference Section No. 2. How to design an underground steam system, with data for solution of problems and descriptions of typical installations. Price, 25c.

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